EFFECT OF NITROGEN ON THE YIELD OF THREE RAPESEED VARIETIES

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CERTIFICATE

This is to certify that the thesis entitled, "EFFECT OF NITROGEN ON THE YIELD OF THREE RAPESEED VARIETIES" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE in AGRONOMY**, embodies the result of a piece of bona fide research work carried out by **MUHAMMAD ABDULLAH-AL-MAMUN,** Registration No. 27504/00690 under my supervision and my guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

Dated: ..27/12/2.0.08
Dhaka, Bangladesh

(Dr. Md. Hazrat Ali)
Professor
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Dedicated To My

Beloved Parents

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ABSTRACT

An experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka-1207, during the period from November, 2006 to March, 2007 with a view to examining the effect of variety and levels of nitrogen on the growth and yield of rapeseed. There were 4 Nitrogen fertilizer treatments in the experiment such as N_0 = Control, N_1 = 60 kg N ha^{-1}, N_2 = 120 kg N ha^{-1} and N_3 = 180 kg N ha^{-1} and three variety viz. SAU Sharisha-1, BARI Sharisha-11 and BARI Sharisha-13 were used in the experiment as the test crop. The experiment was laid out in Randomized Complete Block Design (RCBD) (factorial) with three replications. Variety and nitrogen has significant effect on growth, development, yield and yield attributers of rapeseed. Plant height, dry matter, branches $plant^{-1}$, length of main inflorescence, number of siliquae in the main inflorescence, siliquae $plant^{-1}$, siliqua length, seeds $siliqua^{-1}$, weight of 1000 seed, seed yield, stover yield and harvest index were significantly influenced by both variety and nitrogen. The results revealed that nitrogen at the rate of 120 kg ha^{-1} showed the best result in respect of number of branches $plant^{-1}$ number of siliqua $plant^{-1}$ and number of seeds $siliqua^{-1}$. Nitrogen at 120 kg ha^{-1} gave the highest seed yield (1974.62 kg ha^{-1}). Three varieties influenced the growth parameters like plant height, dry matter weight, and the yield components like branches per plant, length of main inflorescence, number of siliquae in the main inflorescence, siliquae $plant^{-1}$, siliqua length, seeds $siliqua^{-1}$, 1000 seed weight, seed yield, stover yield and harvest index. However, the seed yield of rapeseed significantly differed among the varieties. BARI Sarisha-13 produced the highest yield of 1797.25 kg ha^{-1} and the lowest seed yield (1603.13 kg ha^{-1}) was obtained from the variety SAU Sarisha-1. The interaction effect of variety and nitrogen revealed that three varieties in combination with 120 kg N ha^{-1} showed the best performance in most of the cases.

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ACRONYMS

AEZ	=	Agro- Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BARI	=	Bangladesh Agricultural Research Institute
FAO	=	Food and Agricultural Organization
DAE	=	Days After Emergence
LAI	=	Leaf Area Index
WAS	=	Weeks After Sowing
LAD	=	Leaf Area Duration
N	=	Nitrogen
S	=	Sulphur
P_2O_5	=	Phosphorus Penta Oxide
K_2O	=	Potassium Oxide
DAS	=	Days After Sowing
RCBD		Randomized Complete Block Design
SAU	=	Sher-e- Bangla Agriculture University
HI	=	Harvest Index
%	=	Percent
G	=	Gram (s)
kg	=	Kilogram (s)
TDM	=	Total Dry Matter
cv.	=	Cultivar (s)
T/ha	=	Tones per hectare
CV	=	Coefficient of Variation
hr	=	Hour(s)
ppm	=	Parts per million
P, K, B	=	Phosphorus, Potassium, Boron
CPE	=	Cumulative Pan Evaporation
IW	=	Irrigation Water Depth
CEC	=	Cation Exchange Capacity
mm	=	Millimeter
^{0} C	=	Degree Celsius
M^2	=	Meter squares
NS	=	Non significant
pH	=	Hydrogen ion conc.
cm	=	Centi-meter
LYV	=	Low yielding varieties
HYV	=	High yielding varieties
No.	=	Number
LSD	=	Least significant difference
RDA	=	Recommended Dietary Allowance
var.	=	Variety
et al.	=	And others
etc	=	Etcetera

Chapter 1
Introduction

Chapter 1

INTRODUCTION

The genus *Brassica* of the family Crucifereae has mainly three edible oil producing species namely *Brassica napus, Brassica campestris* and *Brassica juncea* which produce annually a total of 44.41 million tons of seed from an area of 27.24 million hectares (FAO, 2004). Among the species, *Brassica napus* and *Brassica campestris* are regarded as "rapeseed" while *Brassica juncea* is regarded as Indian mustard. Worldwide the total annual production of *Brassica* is rapeseed and mustard which contains 40-45% oil and 20-25% protein in seed.

In Bangladesh, oilseed crops play a vital role in human nutrition. It is not only a rich source of energy (about 9 Kcal/g) but also rich in soluble vitamins A, D, E and K. The National Nutrition Council (NNC) of Bangladesh reported that recommended dietary allowance (RDA) per capita per day should be 6g of oil for a diet with 2700 Kcal. On RDA basis, the edible oil need for 150 millions people per annum is 0.33 million tons of oil equivalent to 0.82 million tons of oilseed (NNC, 1984).

Rapeseed-mustard is one of the important oilseed crops of the world after soybean and palm (FAO, 2004). Sources of edible oil are rapeseed-mustard, sesame, groundnut, soybean, niger, linseed, sunflower, safflower and palm oil in Bangladesh. Rapeseed-mustard is the principal oilseed crop of Bangladesh. In Bangladesh, it covers an area of 0.28 million hectares with a production of 0.21 million tons (BBS, 2005). Rapeseed oil is widely used as cooking oil and as medicinal ingredient and supplies fat in our daily diet. Rapeseed oil cake is used as feed for cattle and fish and as manure for crop production. The average yield of rapeseed in Bangladesh is very low ($0.765\ t\ ha^{-1}$) that is less than 50% of the world average (FAO, 2004).

Domestic production of edible oil almost entirely comes from rapeseed and mustard, occupying only about 2% of total cropped area in Bangladesh (BBS, 2002). The annual oil seed production was about 0.41 million tons of which the share of rapeseed-mustard was 0.21 million tons, which comes about 52 % of the total edible oil seed production (BBS, 2005). It is top of the list in respect of area and production compared to other oilseed crops grown in Bangladesh.

Bangladesh is running with acute shortage of about 70% edible oil. Annually producing about 0.16 million tons of edible oil as against the requirement of 0.5 million tons and to meet the demand, the country has to import oil and oilseeds to the tune of about US $ 160 million per annum (Wahhab *et al.*, 2002).

Different research institute/University in Bangladesh has released quite a number of new high yielding varieties (HYV) of these crops. The yield of HYV cultivars ranges between 1.4 and 2.1 t ha^{-1} (BARI, 2002). However, the yields in farmer's fields are still low compared to their potentialities due to lack of proper management practices. Therefore, there is a scope to increase the yield level of HYVs with proper management practices like spacing, irrigation, fertilizer application and seed rate.

In Bangladesh, both rapeseed and mustard are mostly grown on the residual soil moisture in rabi season (Kaul and Das, 1986). The yield of rapeseed can be augmented with the use of high yielding varieties and appropriate agronomic inputs. Fertilizer is the depending source of nutrient that can be used to boost up growth and yield of mustard (Sinha *et al.*, 2003; Shukla *et al.*, 2002; Meena *et al.*, 2002; Zhao *et al.*, 1997). High yielding varieties of rapeseed are very responsive to fertilizers especially nitrogen and sulphur (Patel *et al.*, 2004; Sharawat *et al.*, 2002; Ali and Rahman, 1986). Application of 100 kg N and 30 kg S ha^{-1} promoted most of the growth parameters and yield attributes of mustard (Islam *et al.*, 2004).

Nitrogen is a very sensitive element to better growth of rapeseed plant. It is highly responsive to nitrogen and this element has tremendous influence on plant height, dry matter accumulation and all the yield attributes at 120 kg N ha^{-1} (Tripathi and Tripathi, 2003; Singh *et al.*, 2002; Shukla *et al.*, 2002; Saikia *et al.*, 2002; Srinivas and Raju, 1997). Excessive use of this element may produce too much of vegetative growth and thus fruit production may be impaired (Sheppard and Bates, 1980). An efficient method and time of application is very much important for proper utilization of nitrogen by plants (Ibrahim *et al.*, 1989). Proper fertilization is an essential need to maximize rapeseed production in Bangladesh soil. The high yielding varieties of rapeseed introduced into intensive cropping system and need through investigation on the variety and N for their growth and development to obtain maximum yield. In view of the limited information on the problems mentioned above the present research work was undertaken with the following objectives:

1. To find out the appropriate dose of nitrogen for getting higher yield of rapeseed.
2. To evaluate the varietal performance for yield abilites.
3. To examine the interaction effect of nitrogen and variety on the growth, yield and yield attributes of rapeseed.

Chapter 2
Review of Literature

Chapter 2

REVIEW OF LITERATURE

Rapeseed-mustard is an important oil crop in Bangladesh, which can contribute largely in the national economy. But the research works done on this crop with respect to agronomic practices are inadequate. The proper fertilizer management accelerates its growth and influenced its yield as well as oil content. Therefore, available findings of the direct effect of irrigation and nitrogen fertilizer and combination effect relevant to the present study have also been briefly reviewed under the following heads:

2.1.1 Plant Height

Sinha *et al.* (2003) fertilized rapeseed cv. B-9 plants with 0, 30, and 60 kg N ha^{-1} under irrigated or non-irrigated condition in a field experiment. They observed that plant height increased with increasing rate of nitrogen and were higher under irrigated than non-irrigated condition. Singh *et al.* (2002) also reported that plant height increased significantly with successive increase in nitrogen up to 120 kg ha^{-1}.

BARI (1999) conducted trial in two different regions of Bangladesh, at Joydebpur and Ishwardi to justify the effect of N on yield of mustard. The experiment kept 3 levels of nitrogen 0, 120, 160 kg ha^{-1} and plant height was found 87.78, 113.94, 106.46 cm, respectively at Joydebpur and 90.79, 118.46, 113.69 cm at Ishwardi. The highest plant height was found in both the locations at 120 kg N ha^{-1}.

Brar *et al.* (1998) observed that each successive increase in nitrogen doses from 100 to 200 kg N ha^{-1}, there was significant increase in plant height. This might be due to the fact that nitrogen plays vital role in both cell division and cell enlargement.

Islam and Mondal (1997) showed that application of nitrogen at the rate of 0, 100, 200, 300 kg ha^{-1}, the maximum plant height was found 93.6 cm at 300 kg N ha^{-1}.

Ali and Ullah (1995) reported that with the application of different doses of nitrogen and maximum plant height was obtain from at 120 kg N ha^{-1}. Singh and Saran (1989) set an experiment with *Brassica campestris* var. Toria and applied different doses of nitrogen. They found that nitrogen at the rate of 60 kg ha^{-1} increased plant height.

Shamsuddin *et al.* (1987) working with five levels of nitrogen (0, 30, 60, 90 and 120 kg N ha^{-1}) and four levels of irrigation, observed that plant height increased progressively with the increasing levels of nitrogen but was not significantly different with the application of different levels of nitrogen. Nitrogen at the rate of 120 kg ha^{-1} gave the highest plant height.

Mondal and Gaffar (1983) observed highest plant height of the variety 'Sampad' by the use of 140 kg N ha^{-1}, which was identical with 105 kg N ha^{-1}.

2.1.2 Dry matter accumulation

Sinha *et al.* (2003) fertilized rapeseed cv. B-9 plants with 0, 30, and 60 kg N ha^{-1} under irrigated or non-irrigated condition. They observed increased dry matter accumulation with increasing rate of nitrogen application.

Shukla *et al.* (2002) conducted an experiment to study the integrated nutrient management for Indian mustard (*B. juncea*). They found highest total dry matter at the application of 120 kg N ha^{-1}. Saikia *et al.* (2002) estimated that the total dry matter significantly responsed with the increasing levels of nitrogen (0, 30, 90, 120 and 150 kg ha^{-1}). Singh *et al.* (2002) also concluded that dry matter accumulation $plant^{-1}$ increased significantly with each successive increase in nitrogen level up to 120 kg ha^{-1}.

Brar *et al.* (1998) carried out a field trial and observed that application of 100, 150 and 200 kg N ha^{-1} dry matter accumulation increased significantly up to 200 kg N ha^{-1}.

Patil *et al.* (1997) worked on *Brassica campestris* with 0, 40, 80 and 120 kg N ha^{-1} and observed the changes in dry matter accumulation in various plant parts. They reported that the application of nitrogen up to 120 kg ha^{-1} had an effect on the increase in leaves, stems and siliquae during the entire period of crop growth. They also reported the beneficial effect of nitrogen on dry matter accumulation for each successive increase in nitrogen dose.

Patra *et al.* (1994) conducted field trial on mustard (*Brassica juncea*) cv. Sarama. The crop was given 20 or 40 kg N ha^{-1}. They found maximum dry matter accumulation after 90 days in mustard with 40 kg N ha^{-1}.

Sharma and Kumar (1990) showed that an application of 120 kg N ha^{-1} increased photosynthetic surface area owing to greater accumulation of photosynthesis and production of more dry matter in Indian mustard.

2.1.3 Number of branches plant^{-1}

Singh *et al.* (2003) reported the effect of row spacing (30, 45 and 60 cm) and nitrogen rates (60, 120 and 180 kg ha^{-1}) and basis of N application (row and even application) on the performance of Indian mustard cv. Basanti. They observed that N at 120 kg ha^{-1} produced higher number of branches per plant compared to 60 kg N ha^{-1}. The N level higher than 120 kg ha^{-1} did not increase the number of branches plant^{-1}.

Tripathi and Tripathi (2003) performed an experiment to investigate the effect of N levels (80, 120, 160 and 200 kg ha^{-1}) on the branches number of Indian mustard cv. Varuna. Nitrogen was applied at 3 equal splits, at sowing, at first irrigation and 60 days after sowing. Results showed that the number of primary branches per plant increased up to 200 kg N ha^{-1}.

Shukla *et al.* (2002) conducted an experiment to study the integrated nutrient management for Indian mustard (*B. juncea*). They found that the highest number of branches per plant was obtained with the application of 120 kg N/ha.

Singh *et al.* (2002) reported that primary and secondary branches per plant increased significantly with each successive increase in nitrogen up to 120 kg ha^{-1}.

Sharma and Jain (2002) conducted an experiment with five levels of nitrogen (0, 40, 80, 120 and 160 kg ha^{-1}) followed by the cropping system that the application of 80 kg N ha^{-1} resulted the highest number of branches (24.4) $plant^{-1}$.

Mondal *et al.* (1996) grew four rapeseed genotypes with five levels of nitrogen and observed that number of primary branches $plant^{-1}$ increased progressively with the increasing nitrogen doses and the highest number of primary branches $plant^{-1}$ was obtained from the highest level of nitrogen (250 kg N ha^{-1}).

Tarafder and Mondal (1990) reported from an experiment conducting for determining the effect of nitrogen and sulphur on seed yield of mustard (var. Sonali Sarisha) and found that the number of branches $plant^{-1}$ increased with the increasing levels of nitrogen (120 kg N ha^{-1}).

Shamsuddin *et al.* (1987) working with five levels of nitrogen (0, 30, 60, 90 and 120 kg N ha^{-1}) and four levels of irrigation and observed that nitrogen at the rate of 120 kg ha^{-1} gave highest number of primary branches $plant^{-1}$ (5.03).

Patel *et al.* (1980) observed the highest number of branches $plant^{-1}$ at 50 kg N ha^{-1} among the four levels of nitrogen (0, 25, 50 and 75 kg ha^{-1}). Primary and secondary branches $plant^{-1}$ significantly increased with the increase in nitrogen levels from 0 to 100 kg N ha^{-1} and the highest number of primary and secondary branches $plant^{-1}$ was observed with the highest level of nitrogen.

2.1.4 Number of siliquae plant $^{-1}$

Ozer (2003) studied two cultivars (Tower and Lirawell) of rapeseed to investigate the effect of sowing dates with four levels of nitrogen (0, 80, 160 and 240 kg N ha^{-1}). He observed that adequate N fertilization is important in increasing siliquae number plant^{-1} and observed highest siliquae number plant^{-1} of summer oilseed rape at the rate of 160 kg N ha^{-1}.

Singh *et al.* (2003) reported from an experiment conducting for determining the effect of row spacing (30, 45 and 60 cm) and nitrogen rates (60, 120 and 180 kg ha^{-1}) on the performance of Indian mustard cv. Basanti. They observed that N at 120 kg ha^{-1} produced higher number of siliquae plant^{-1} (48.03), siliquae weight (2.09) compared to 60 kg N ha^{-1}. The N level higher than 120 kg ha^{-1} did not increase the number of siliquae significantly.

Sharma and Jain (2002) studied with five levels of nitrogen (0, 40, 80, 120 and 160 kg ha^{-1}) followed by the cropping system that the application of 80 kg N ha^{-1} resulted in the highest number of siliquae plant^{-1} (260.9). Singh *et al.* (2002) also reported that siliquae per plant increased significantly with each successive increase in nitrogen up to 120 kg ha^{-1}.

Shukla *et al.* (2002) performed an experiment to observe the integrated nutrient management for Indian mustard (*Brassica juncea*). They found that maximum number of siliquae plant^{-1} was obtained with the application of 120 kg N ha^{-1}.

BARI (1999) investigated in a field trial with the application of 0, 80, 120, 140 N kg ha^{-1} and siliquae plant^{-1} were found 22.7, 42.0, 45.6, and 48.0 respectively.

Singh and Saran (1989) set an experiment with *Brassica campestris* var. Toria and applied different doses of nitrogen. They found that nitrogen at the rate of 60 kg ha^{-1} increased the number of siliquae plant^{-1}.

Shamsuddin *et al.* (1987) working with five levels of nitrogen (0, 30, 60, 90 and 120 kg N ha^{-1}) and four levels of irrigation and observed that N at the rate of 120 kg ha^{-1} significantly increased the number of siliquae $plant^{-1}$.

2.1.5 Length of siliquae

Singh (2002) conducted an experiment with Varuna variety of mustard having 5 levels of nitrogen (0, 30, 60, 90 and 120 kg ha^{-1}) and five levels of P (0, 15, 30, 45 and 60 kg ha^{-1}). Application of N and P increased the length of siliqua. However, the significant increase in length of siliqua was recorded up to 120 kg N ha^{-1} with 60 kg P ha^{-1}.

Shukla *et al.* (2002) conducted an experiment to study the integrated nutrient management for Indian mustard (*B. juncea*). They observed maximum siliquae length with the application of 120 kg N ha^{-1}. Singh *et al.* (2002) also reported that growth characters length of siliqua increased significantly with the successive increase in nitrogen up to 120 kg ha^{-1}.

Singh and Saran (1992) set an experiment with *Brassica campestris* var. Toria and applied different doses (0, 40 and 80 kg N ha^{-1}) of nitrogen. They found that nitrogen application significantly increased the siliqua length up to 80 kg N ha^{-1}. Effect of nitrogen was noticed only up to 40 kg ha^{-1} on yield attributes, such as primary branches $plant^{-1}$, siluquae $plant^{-1}$, siliqua length. Favorable effect of N on these yield attributes can be explained that application of N resulted in higher leaf-area index and dry matter accumulation and its translocation to reproductive parts.

2.1.6 Number of seeds $siliqua^{-1}$

Sharma and Jain (2002) conducted an experiment with five levels of nitrogen (0, 40, 80, 120 and 160 kg ha^{-1}) followed by the cropping system that the application of 80 kg N ha^{-1} resulted in the highest number seeds $siliqua^{-1}$ (15.3).

Singh (2002) conducted an experiment with Varuna variety of mustard having 5 levels of nitrogen (0, 30, 60, 90 and 120 kg ha^{-1}) and five levels of P (0, 15, 30, 45 and 60 kg ha^{-1}). Application of N and P increased the number of seeds $siliqua^{-1}$. However, the significant increase in length of siliquae was recorded up to 120 kg N ha^{-1} with 60 kg P ha^{-1}.

Shukla *et al.* (2002) conducted an experiment to study the integrated nutrient management for Indian mustard (*B. juncea*). They obtained maximum number of seeds $siliqua^{-1}$ when nitrogen was applied at 120 kg ha^{-1}.

Generally, the number of seeds $siliqua^{-1}$ increased with increasing levels of N. Hossain and Gaffer (1997) observed that number of siliquae $plant^{-1}$, number of seeds $siliqua^{-1}$ and 1000 seed weight varied significantly with mustard varieties and the highest number of siliquae $plant^{-1}$ and 1000 seed weight and grain yield were obtained with 250 kg N ha^{-1}.

Tomar *et al.* (1997) worked with Indian mustard with 3 levels of nitrogen (60, 120 and 180 kg ha^{-1}) and showed that yield attributes (siliquae $plant^{-1}$, seeds $siliqua^{-1}$ and 1000 seed weight) increased significantly with every increase in N up to 180 kg ha^{-1}. Due to enhanced growth attributes that diverted the photosynthesis to reproductive organs for the formation of large sized, number of seeds of higher seed weight that ultimately increased the yield ha^{-1}.

2.1.7 Weight of 1000 seeds

Ozer (2003) studied two cultivars (Tower and Lirawell) of rapeseed to investigate the effect of sowing dates with four levels of nitrogen (0, 80, 160 and 240 kg N kg^{-1}). He observed that adequate N fertilization is important in increasing 1000 seed weight in summer oilseed rape and suggested that the rate of 160 kg N ha^{-1} will be adequate for the crop to meet its N requirements. 1000 seed weight differs with nitrogen levels that enhanced yield.

Singh (2002) conducted an experiment with Varuna variety of mustard having 5 levels of nitrogen (0, 30, 60, 90 and 120 kg ha^{-1}) and five levels of P (0, 15, 30, 45 and 60 kg ha^{-1}). Application of N and P increased 1000 seed weight.

However, the significant increase in 1000 seed weight was recorded in 120 kg N ha^{-1}.

Sharma and Jain (2002) conducted an experiment with five levels of nitrogen (0, 40, 80, 120 and 160 kg ha^{-1}) followed by the cropping system that the application of 80 kg N ha^{-1} resulted higher 1000 seed weight (3.55 g).

Shukla *et al.* (2002) conducted an experiment to study the integrated nutrient management for Indian mustard (*B. juncea*). They obtained maximum 1000 seed weight with the application of 120 kg N ha^{-1}.

Singh and Saran (1989) set an experiment with *Brassica campestris* var. Toria and applied different doses of nitrogen. They found that nitrogen at the rate of 60 kg ha^{-1} increased 1000 seed weight.

Shamsuddin *et al.* (1987) working with five levels of nitrogen (0, 30, 60, 90 and 120 kg N ha^{-1}) and four levels of irrigation and observed that 1000 seed weight increased progressively with the successive increase of N rate up to 120 kg ha^{-1}.

2.1.8 Seed yield

Sinsinwar *et al.* (2004) observed the increased seed yield of Indian mustard with each increment of N fertilizer up to 60 kg ha^{-1} beyond this the increase was marginal. On an average, the increase in seed yield compared to the control was 33.3 and 83.8% with 30 and 60 kg N ha^{-1} respectively.

Singh (2004) conducted a field experiment using blue green algae (BGA) and *Azolla* in integration with graded levels of N fertilizer in rice followed by rapeseed. *Azolla* were found better in seed yield with regard to the effect on subsequent crop of rapeseed and the highest yield was recorded with higher dose of N (80 kg N ha^{-1}) in integration with *Azolla.*

India was assessed the impact of different agronomical input comprising various combinations of thing (15 and 25 days after sowing, DAS) weeding (40

DAS ,) fertilizer (N at 100, P at 40 and K at 40 kg ha^{-1}) , fungicide (Mancozebat 0.2%) and insecticide (Oxydemeton-methyl 25 EC at0.025%) in three replications following randomized block design and significantly superior seed yield (801.67 Kg ha^{-1}) with higher net monetary return (R.S.86467 ha) was noticed on crop grown under the full package . The crop raised with all input. The application of these inputs provided better crop growth in comparison to untreated crop. The lowest seed yield (597.67 Kg ha^{-1}) was recorded on untreated crop compared to treat ones (Malik *et al.* 2003).

Singh *et al.* (2003) reported from an experiment conducting for determining the effect of row spacing (30, 45 and 60 cm) and nitrogen rates (60, 120 and 180 kg ha^{-1}) on the performance of Indian mustard cv. Basanti. They observed that N at 120 kg ha^{-1} produced higher seed yield (2.55 q ha^{-1}) compared to 60 kg N ha^{-1}. The N level higher than 120 kg ha^{-1}, did not increase the yield significantly.

Tripathi and Tripathi (2003) performed an experiment to inspect the effect of N levels (80, 120, 160 and 200 kg ha^{-1}) on the yield of Indian mustard cv. Varuna. Nitrogen was applied at 3 equal splits, at sowing, at first irrigation and 60 days after sowing. Results showed that seed yield increased with increasing N levels up to 160 kg N ha^{-1}. Singh and Prasad (2003) reported that 120 kg N ha^{-1} gave the highest seed yield (20.24 q ha^{-1}). But the highest cost benefit ratio (0.85) was obtained with 180 kg N ha^{-1}.

Kumar and Singh (2003) reported significant increase in seed yield (1617 kg ha^{-1}) with nitrogen at 150 kg ha^{-1}. Addition of 50 kg N ha^{-1} resulted in producing 8.62 kg of seed kg^{-1} of N applied. The maximum yield (24.51 q ha^{-1}) was obtained from 20-25 October sown crops with 40 cm row spacing and supplied with 150 kg N ha^{-1}.

Khan *et al.* (2003) studied the interactive effect of nitrogen (0, 40, 60 and 80 kg ha^{-1}) and plant growth regulators (cycocel and ethrel both at 200 or 400 ppm) on the photosynthetic biomass production and partitioning in response of seed yield of Indian mustard cv. Alankar and found that 80 kg N ha^{-1} and ethrel at 200 ppm increased the seed yield.

Ozer (2003) studied the effect of sowing dates with four levels of nitrogen (0, 80, 160 and 240 kg N ha^{-1}) on two cultivars of rapeseed. He observed that adequate N fertilization is important in yield formation in summer oilseed rape and suggested that the rate of 160 kg N ha^{-1} will be about adequate for the crop to meet its N requirements.

Sharma and Jain (2002) conducted an experiment with five levels of nitrogen (0, 40, 80, 120 and 160 kg ha^{-1}) followed by the cropping system that the application of 80 kg N ha^{-1} resulted in the highest seed yield (1649.22 kg ha^{-1}). The highest values of seed yield and yield attributes were recorded for S. *canabina* – Indian mustard receiving 80 kg N ha^{-1}.

Shukla *et al.* (2002) also conducted an experiment to investigate the effect of S (0 or 40 kg ha^{-1}) and N (60, 90 or 120 kg ha^{-1}) on the yield and yield attributes of rape cultivars. Sulphur did not significantly affect the seed yield and yield attributes. But N at 120 kg ha^{-1} produced higher seed yield than N at 60 and 90 kg ha^{-1}.

Singh (2002) conducted a study with variety Varuna of mustard having 5 levels of nitrogen (0, 30, 60, 90 and 120 kg ha^{-1}) and five levels of P (0, 15, 30, 45 and 60 kg ha^{-1}). Application of N and P increased the seed yield. However, the significant increase in seed yield was recorded up to 120 kg N ha^{-1} with 60 kg P ha^{-1}. The maximum seed yields (12.98 and 13.83 q ha^{-1}) were obtained with the application of nitrogen at 120 kg ha^{-1}.

Shukla *et al.* (2002) investigated the integrated nutrient management for Indian mustard (*B. juncea*). They observed maximum seed yield ha^{-1} with the application of 120 kg N ha^{-1}.

Ghosh *et al.* (2001) conducted an experiment to study the response of 3 levels of K (0, 12.5 and 25 kg ha^{-1}), 3 levels of N (0, 40 and 80 kg ha^{-1}) and biofertilizers (*Azotibacter*, *Azospirillum*) under irrigated condition. Interaction between K and biofertilizers and between biofertilizer and N were found significant in increasing the yield of rapeseed. They observed that maximum yield of rapeseed was obtained followed by the yield obtained with 80 kg N/ha along with 12.5 kg K ha^{-1}.

Sidlauskas (2000) found that the yield of rapeseed was increased with the increasing rate of nitrogen levels up to 120 kg ha^{-1}. Further increase of nitrogen level did not affect the seed yield.

BARI (1999) investigated with 4 levels of nitrogen (0, 80,120,140 kg ha^{-1}) on different varieties of mustard and yields were found 493.3, 833.3, 940.0, 993.7 kg ha^{-1} respectively. Zekaite (1999) also reported that, the seed yield of rapeseed (0.88 t ha^{-1}) was obtained at a nitrogen fertilization of 90 kg ha^{-1}. Fertilization of nitrogen at 120 kg ha^{-1} significantly increased the seed yield.

Patel (1998) conducted an experiment to study the response of mustard (*Brassica juncea*) cv. Varuna to 3 levels of irrigation and 4 levels of nitrogen (0, 20, 40 and 80 kg ha^{-1}). He obtained seed yield averaged 0.43, 0.73, 0.95 and 1.21 t ha^{-1} with 0, 20, 40 and 60 kg N ha^{-1}, respectively. Singh *et al.* (1998) reported that seed and oil yields as well oil component values were increased with increasing nitrogen rates (0, 40, and 80 kg N ha^{-1}).

Shukla and Kumar (1997) reported that six varieties of Indian mustard were grown to assess the effect of nitrogen fertilization on yield attributes, seed yield and oil content. They found that N application at 120 kg ha^{-1} significantly influenced the seed yield.

Gurjar and Chauhan (1997) observed that *Pusa Bold* and *Kranti* were grown in winter seasons at 5 N + P levels and at row spacing of 30 cm or 45 cm. They found that seed yield did not differ between cultivars, was greater at 30 cm spacing (1.68 vs. 1.12 t ha^{-1}) and increased up to 75 kg N + 50 kg P2O5 ha^{-1}.

Islam and Mondal (1997) in a field trial showed that application of four levels of nitrogen 0, 100, 200, 300 kg ha^{-1} yielded 0.69, 1.29, 1.45, 1.21 t ha^{-1} seeds, respectively. They observed increased seed yield up to 200 kg N ha^{-1}.

Hossain and Gaffer (1997) conducted a trial with 5 levels of nitrogen at 0, 100, 150, 200, 250, kg ha^{-1} on rapeseed and maximum yield was found 1.73 t ha^{-1} with 250 kg N ha^{-1}.

Thakuria and Gogoi (1996) conducted an experiment on *Brassica juncea* cv, TM 2, TM 4 and Varuna to evaluate the effect of 2 row spacing with 4 levels of nitrogen fertilizer (0, 40, 80 and 120 kg N ha^{-1}). Seed yield and yield components significantly increased with increasing N application up to 80 kg ha^{-1}.

Tuteja *et al.* (1996) investigated the effect of nitrogen at 60, 90 and 120 kg ha^{-1} on the yield of *Brassica juncea* cv. Varuna. Seed yield was highest (1.12 t ha^{-1}) with 120 kg N ha^{-1}.

Mondal *et al.* (1996) reported that the highest seed yield of rapeseed (1.40 t/ha) was obtained from fertilizer levels of 150:90:100:30:4:1 kg ha^{-1} of N, P2O5, K2O, S, Zn and B with 6 tones of cow dung. This level of fertilizer was the most profitable among the 5 levels of fertilizers. Arthamwar *et al.* (1996) conducted an experiment with mustard variety (Pusa Bold and T-59) having both the 3 levels of N (0, 50 and 100 kg ha^{-1}) and P2O5 (0, 40 and 80 kg ha^{-1}). Result showed that highest seed yield obtained with N at of 100 kg ha^{-1} (1.20 t ha^{-1}) and 80 kg P2O5 (1.25 t ha^{-1}).

Dobariya and Mehta (1995) also reported that increasing nitrogen rate from 25 to 75 kg ha^{-1} increased seed yield from 2.07-2.41 t ha^{-1}. Letu *et al.* (1994) also reported that application of 3 levels of N at 0, 120, 160 kg ha^{-1} produced the seed yield of 1.3, 1.4 and 1.5 t ha^{-1}, respectively.

Tarafder and Mondal (1990) set an experiment to evaluate the effect of nitrogen and sulphur on seed yield of mustard (var. Sonali Sarisha) and found that seed yield increased with increasing levels of nitrogen or both nitrogen and sulphur.The results suggested that the nitrogen at the rate of 120 kg ha^{-1} did produce the economic seed yield in mustard in the grey terrace soil of Joydebpur.

Perniona *et al.* (1989) studied the effect of nitrogen (50, 100 and 150 kg ha^{-1}) on winter rape and found that average seed yield increased with the increased rate of nitrogen at 150 kg ha^{-1}.

Singh and Saran (1989) set an experiment with *Brassica campestris* var. Toria and applied different doses of nitrogen. They found that nitrogen at the rate of 60 kg ha^{-1} increased the seed yield. This dose gave seed yields of 1.20 t ha^{-1} compared to 0.89 t ha^{-1} without nitrogen. A further increase in yield with 90 kg ha^{-1} was not significant.

Shamsuddin *et al.* (1987) working with five levels of nitrogen (0, 30, 60, 90 and 120 kg N ha^{-1}) and four levels of irrigation and observed that different levels of nitrogen did not significantly differed the seed yield. Nitrogen at the rate of 120 kg ha^{-1} gave seed yield of 830 kg ha^{-1}.

Mondal and Gaffer (1983) conducted experiment with Sampad variety of mustard having 5 levels of N (0, 35, 70, 105 and 140 kg ha^{-1}) and four levels of P2O5 (0, 35, 70 and 105 kg ha^{-1}). The highest seed yield (1280.95 kg ha^{-1}) was obtained from N treatment of 140 kg ha^{-1} which was found identical with that of 105 kg ha^{-1}.

2.1.9 Stover yield

Prasad *et al.* (2003) reported the effect of N, S and Zn fertilizers on the nutrient uptake, quality and yield of Indian mustard cv. Vaibhav. The treatments consisted of 60 kg N ha^{-1} singly or in combination with 30 kg P, 20 kg S, 5 kg Zn; 30 kg P + 20 kg S; 30 kg P + 5 kg Zn; 20 kg S + 5 kg Zn; or 30 kg P + 20 kg S + 5 kg Zn/ha. N, P, S and Zn were applied through urea, diammonium phosphate, gypsum and zinc oxide respectively. The application of 60 kg N + 30 kg P + 20 kg S + 5 kg Zn and 60 kg N + 30 kg P + 20 kg S ha^{-1} gave the highest stover yield (33.08 q ha^{-1}). Singh and Prasad (2003) also mentioned that 120 kg N ha^{-1} gave the highest stover yield (12.22 q ha^{-1}).

Meena *et al.* (2002) conducted an experiment to study the effect of nitrogen, irrigation and intercultural operation on yield and yield attributes of mustard. The results of experiment revealed that the application of 60 kg N ha^{-1} registered significantly higher stover yield of mustard over control. Singh *et al.* (2002) also reported that stover yield increased significantly with successive increase in nitrogen up to 120 kg ha^{-1}.

2.1.10 Harvest index (%)

Harvest index or the capacity to convert biomass into harvestable organs has been recognized as an important selection criterion for many crops (Donald, 1963). Thus the increase in yield of cereals during past decades has been associated with the improvement of harvest index. Nitrogen fertilizer influences the harvest index.

Cheema *et al.* (2001) reported that increased fertilizer application up to 90 kg N ha^{-1} increased the harvest index. Kachroo and Kumar (1999) also got higher harvest index at higher N rates.

Shukla and Kumar (1997) grew six varieties of Indian mustard to assess the effect of nitrogen fertilization on yield attributes, seed yield and oil content. They found that N application at the rate of 120 kg ha^{-1} significantly influenced harvest index.

Ali *et al.* (1996) observed that harvest index invariably increased owing to increased rate of N application. Ali and Ullah (1995) obtained the maximum harvest index in rapeseed with 120 kg N ha^{-1}.

Patel *et al.* (1980) reported that highest seed yield was achieved at the rate of 50 kg N ha^{-1} due to the formation of higher harvest index in rapeseed.

Chapter 3
Materials and Methods

Chapter 3
MATERIALS AND METHODS

The experiment was undertaken to examine the effect of nitrogen on the yield of rapeseed varieties.

3.1 Location

The research was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka-1207, during the period from November, 2006 to March, 2007.

3.2 Site selection

The experimental field was located at $90^0 22'$ E longitude and $23^0 41'$ N latitude at an altitude of 8.6 meters above the sea level. The land was in Agro-ecological zone of "Madhupur Tract" (AEZ No. 28). It was Deep Red Brown Terrace soil and belonged to "Nodda" cultivated series. The soil was clay loam in texture having pH 5.55. The physical and chemical characteristics of the soil have been presented in Appendix I.

3.3 Climate

Cold temperature and minimum rainfall is the main feature of the rabi season. Monthly total rainfall, average sunshine hour and temperature during the study period (November to March) are shown in Appendix II.

3.4 Variety

SAU Sharisha-1, BARI Sharisha-13 and BARI Sharisha-11, were used in the experiment as the test crop. All varieties leaves are deep green, smooth and hairless and look like leaves of cauliflower. Leaves are without petiole and base of the leaf clasped half of the stem. Open flower lies below the bud. In each plant there are 60 to 70 siliquae. Siliquae is long, two chambered and each siliqua contains 25-30 seeds. Seeds are big and 1000 seed weight is 3.5 g. The seeds of BARI Sarisha-11 & BARI Sarisha-13 are blackish and the seeds of SAU Sarisha-1 are whitish in colour. Plant height is 0.8 to 1.0 m. There are 4-5 primary branches $plant^{-1}$. Flowers are yellow in colour. First flower is seen after 25-30 days of sowing. Duration of flowering stage is longer than the other varieties. It takes 95-100 days to mature. Per hectare yield ranges from 2100 to 2400 kg ha^{-1}. The seeds of BARI Sarisha-11 and BARI Sarisha-13 were collected from the Oilseed Research Centre, Bangladesh Agricultural Research Institute, Gazipur-1701 and the seeds of SAU Sarisha-1 are collected from Department of Genetics and Plant Breeding, Sher-e- Bangla Agricultural University, Dhaka-1207. Before sowing, germination test was carried out in the laboratory and percentage of germination was over 95.

3.5 Lay out of the experiment

The experiment was laid out in a Randomized Complete Block Design (RCBD) (factorial) with three replications. There were 3 varieties treatments and 4 nitrogen fertilizer treatments for rapeseed. In the experiment, there were 3 replications and the total numbers of plots were 12×3=36. The size of each unit plot was 2.7m × 4.0m = 10.8 m^2. The replications were separated from one another by 1.0 m.

3.6 Varietal treatments under investigation

There were 3 varietal treatments in the experiment. The treatments were

1. V_1 = SAU Sarisha-1
2. V_2 = BARI Sarisha-11; and
3. V_3 = BARI Sarisha-13

3.7 Fertilizer treatments

There were 4 Nitrogen fertilizer treatments in the experiment. The standard rate of P_2O_5 @ 86 kg ha^{-1}, K_2O @ 60 kg ha^{-1}, Sulphur @ 32 kg ha^{-1}, zinc oxide @ 5 kg ha^{-1} and Boric acid @ 10 kg ha^{-1} were applied to all the plots (BARI, 2001). There were four levels of N:

1. N_0 = Control
2. N_1 = 60 kg N ha^{-1}
3. N_2 = 120 kg N ha^{-1} and
4. N_3 = 180 kg N ha^{-1}

3.8 Details of the field operations

The particulars of cultural operations carried out during the experimentation are presented below.

3.8.1 Land preparation

The land was ploughed with a rotary plough and power tiller. Ploughed soil was then brought into desirable fine tilth and leveled by four of ploughing operations and repeated laddering. The land was fellow, so the weeds of fellow land were cleaned properly. The final ploughing and land preparation was done on November 12, 2006.

3.8.2 Application of fertilizer

The amounts of fertilizer in the forms of urea, triple super phosphate, muriate of potash, gypsum, zinc oxide and boric acid required plot^{-1} were calculated from fertilizer doses. During final land preparation one - half of urea and total amount of all other fertilizers were applied and incorporated into soil. Rest of the urea as treatment^{-1} was top dressed after 30 days of sowing (DAS).

3.8.3 Sowing and seed rate

The seeds were sown on November 13, 2006. Seeds were sown continuously in 30 cm apart in rows at the rate of 9 kg ha^{-1} on good tilth soil condition to conserve moisture, which ensured satisfactory germination of seeds. After sowing; the seeds were covered with the soil and slightly pressed by hand. Plant populations were kept constant through maintaining plant to plant distance 5 cm in rows.

3.8.4 Thinning and weeding

The optimum plant population was maintained by thinning 15 DAS. At final thinning plant spacing within rows was maintained 5 cm plant to plant distance in rows. Thinning was done in the entire plots with special care as to maintain a constant plant population in the entire plot. One weeding with khurpi was given 25 days after sowing.

3.8.5 Pest and disease management

The crop was sprayed with Malathion 57 EC @ 2 ml per liter of water, at siliqua formation stage to control aphids.

3.8.6 Harvesting and threshing

The crop was harvested when 80% of the siliquae in terminal raceme turned golden yellow in colour. The crop maturity varied with fertilizer and irrigation treatments. Samples were collected from different places of each plot leaving undisturbed one meter square in the centre. After collecting sample plants, harvesting was started on March 20 and completed on March 25, 2007. The harvested crops were tied into bundles, tagged and carried to the clean cemented threshing floor. The crop bundles were sun dried by spreading those on the threshing floor. The seeds were separated from the plants by beating the bundles with bamboo sticks.

3.8.7 Drying and weighing

The seeds thus collected were dried to 6-8 % moisture contents. The stovers were also dried in the sun. Dried seeds and stovers of each plot was weighed and subsequently converted into kg ha^{-1}.

3.9 Collection of experimental data

For the convenient of collecting data, ten plants per plot were randomly selected and tagged for recording various yield contributing characters and yield. But for estimation of total dry matter, five plants were selected per plot for each time (30, 45, 60, 75 DAS and at harvest) at different growth stages of plant.

3.9. 1 Plant height (cm)

At different stages of crop growth for all treatments the height of five randomly selected plants were measured from the base to the tip of the plant and mean plant height was determined. The plant height was measured at 30, 45, 60, 75 DAS and at harvest.

3.9.2 Total dry matter (g/plant)

Dry matter at 30, 45, 60, 75 days after sowing and at harvest was observed and average was recorded.

3.9.3Number of primary branches plant^{-1}

The primary branches were counted from the ten tagged plants in each plot at harvest and average was taken.

3.9.4 Number of secondary branches plant^{-1}

The ten tagged plants in each plot were also used for counting the number of secondary branches at harvest. The secondary branches which borne at least one siliquae, were termed productive secondary branches and these were counted at harvest and expressed on plant^{-1} basis.

3.9.5 Length of main inflorescence (cm)

The ten tagged plants in each plot were also used for measure the length of main inflorescence. The main axis length represents the section of plant from point of initiation of first siliquae of most branches is termed as main inflorescence. These lengths were measured at harvest and expressed on main inflorescence basis.

3.9.6 Number of siliquae in the main inflorescence

Number of siliquae for each main inflorescence of ten tagged plants was counted at harvest.

3.9.7 Number of siliquae plant^{-1}

The number of siliquae from ten tagged plants were counted after the harvest and expressed on plant^{-1} basis.

3.9.8 Length of siliqua (cm)

Length of ten siliquae was randomly collected from the ten tagged plants and average length per siliqua was calculated.

3.9.9 Number of seeds siliqua^{-1}

At the time of counting the number of siliquae, all the siliquae of ten plants were thoroughly mixed and twenty siliquae were taken from this lot for counting the seeds and was made average to find out the number of seeds siliqua^{-1}.

3.9.10 Weight of 1000 seeds (g)

A composite sample was taken from the yield of ten tagged plants. 1000 seeds of each plot were counted and weighed with a fine electric digital balance. The 1000 seed weight was recorded in g.

3.9.11 Seed yield (kg ha^{-1})

1m × 1m = 1m^2 areas were selected in middle area of each plot for recording seed yield per hectare. The total produce from the net area of each plot was cleaned, weighted, and computed the seed yield in kg ha^{-1}.

3.9.12 Stover yield (kg ha^{-1})

Before threshing, the total biological yield from the net area was recorded. Later, the stover per net area of each plot was obtained by deducting the seed yield plot^{-1} from the biological yield plot^{-1} and used to compute the stover yield in kg ha^{-1}.

3.9.13 Harvest index (%)

Harvest index was calculated by dividing the economic (seed) yield from the net plot by the total biological yield (seed+stover) from the same area (Donald, 1963) and multiplying by 100:

$$\text{Harvest index} = \frac{\text{Seed yield (t ha}^{-1}\text{)}}{\text{Biological yield (t ha}^{-1}\text{)}} \times 100$$

3.10 Soil sampling

Three composite soil samples were collected within 15 cm depth of soil profile, taking one from each block at first ploughing. Each composite sample was a mixture of 10 samples obtained from ten different spots in each block. Collected samples were air dried and ground to pass a 10-mesh sieve and stored in polythene bags for laboratory analysis. Soil analysis was done at Soil Resources Development Institute (SRDI).

3.11 Statistical analysis

The collected data were complied and analyzed by RCBD (factorial) design to find out the statistical significance of experimental results. The collected data were analyzed by MSTAT software (Russell, 1986). The means for all recorded data were calculated and the analyses of variance for all characters were performed. The mean differences were evaluated by the Least Significant Difference (LSD) test.

Chapter 4
Results and Discussion

Chapter 4

RESULTS AND DISCUSSION

The results of the present study have been discussed in this chapter. The growth parameters are plant height and total dry matter plant^{-1}. The yield and yield contributing characters are number of primary branches plant^{-1}, number of secondary branches plant^{-1}, length of main inflorescence, number of siliquae in main inflorescence, number of siliquae plant^{-1}, siliquae length, number of seeds siliquae^{-1}, 1000 seed weight, seed yield ha^{-1}, stover yield ha^{-1} and harvest index have been presented in different tables and figures. Chemical composition of some *Brassica* oilseeds has been presented in appendix III. The analyses of variance in respect of all the characters under study have been presented in Appendix IV-VI. The detailed experimental findings have been explained and discussed below with supporting references wherever possible.

4.1 Plant height (cm)

4.1.1 Effect of variety

A significant variation was found among the varieties (Fig. 1) for plant height at 30 DAS, 60 DAS, and 75 DAS and at harvest of rapeseed except 45 DAS. At 30 DAS the tallest plant height (12.25cm) was observed from BARI Sarisha-13 and smallest was (10.50cm) from SAU Sarisha-1 which was statistically identical with BARI Sarisha-11 (11.17cm). At 60 DAS, 75 DAS and at harvest of the tallest plant (75.11, 99.01 and 101.17cm, respectively) were showed in the treatment BARI Sarisha-13, which was statistically identical with similar than BARI Sarisha-11 (73.99, 98.37 and 100.96cm) and the smallest were found (71.67, 96.24 and 98.16cm) from the SAU Sarisha-1 treatment throughout the life cycle. Similar varietal significant variation also was found by Bhuiyan *et al.* (1989) observed significant variation in plant height in different varieties of mustard and rapeseed. Jahan and Zakaria (1997) observed that BARI Sharisa 6 was the tallest plant (142.5 cm) which was at par with Sonali (139.5 cm) and Jatarai (138.6 cm). The shortest plant was observed in tori-7 (90.97 cm). Mondal *et al.* (1992) observed the highest plant height (134.4 cm) in the variety J-5004, which was identical with SS-75 and significantly taller than TS-72 and Tori-7.

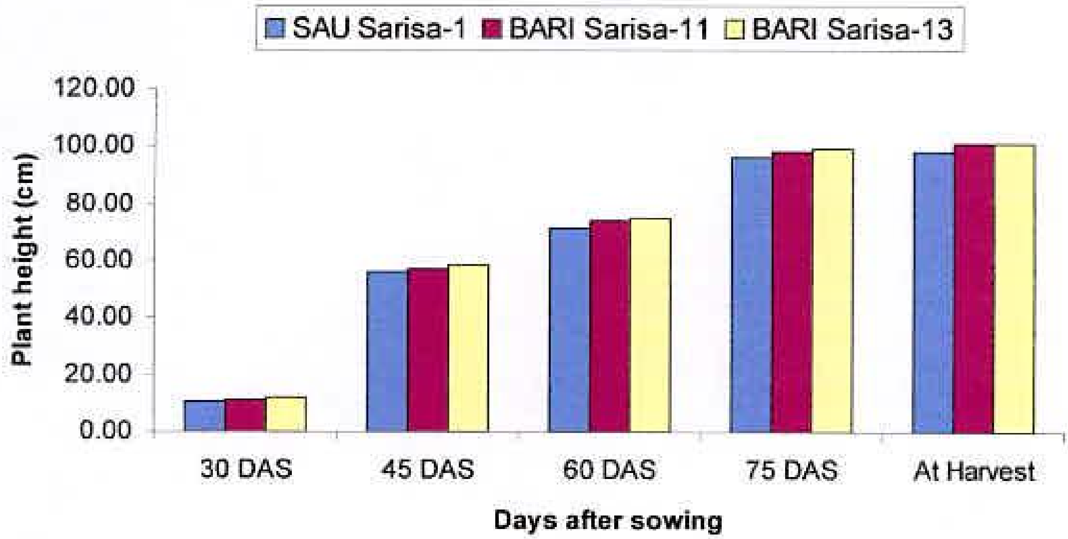

Fig 1. Effect of variety on plant height (cm) of rapeseed at different days after sowing (DAS)

4.1.2 Effect of nitrogen

Each successive increase of nitrogen increased the plant height significantly. It was observed from Fig. 2 that plant height varies due to variation of nitrogen at different growth stages. Application of 180 kg N ha^{-1} produced the tallest plant height and the shortest plant height was produced due to control treatment. This might be due to the fact that nitrogen plays vital role in both cell division and cell enlargement. These findings ware in agreement with those of Sinha *et al.* (2003), Tripathi and Tripathi (2003), Singh *et al.* (2002). Tarafder and Mondal (1990) they observed that plant height increased with increasing rate of nitrogen but successive increase in nitrogen up to 120 kg ha^{-1}. Patel *et al.* (1998), Shamsuddin *et al.* (1987), Gurjar and Chauhan (1997), Thakuria and Gogoi (1996) revealed taller plant height at 140 kg N ha^{-1} which was identical with that of 105 kg N ha^{-1}. Maximum plant height was recorded at 100 kg N ha^{-1} reported by Patel *et al.* (2004).

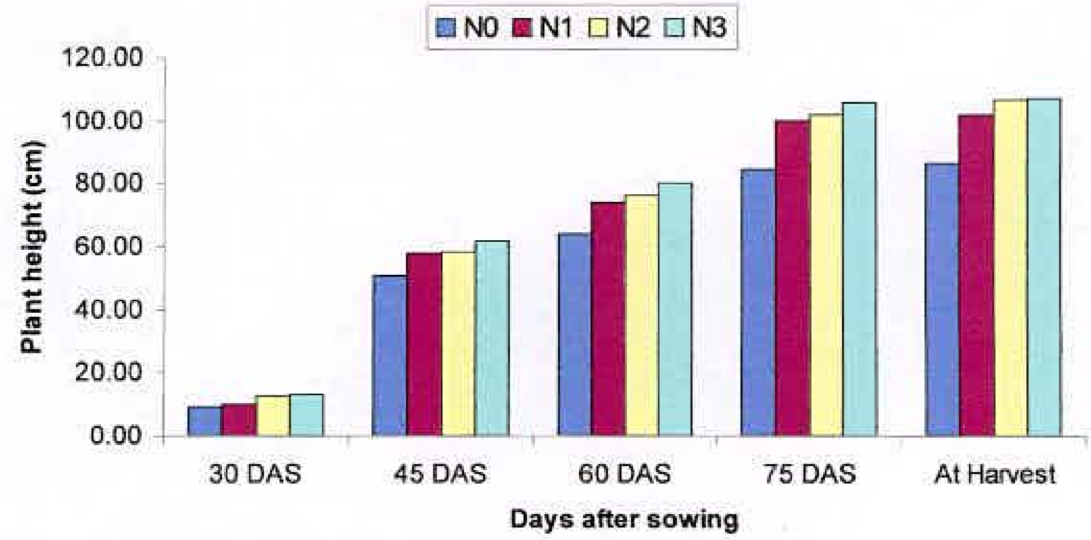

Fig 2. Effect of levels of nitrogen on plant height (cm) of rapeseed at different days after sowing (DAS)

4.1.3 Interaction effect of variety and nitrogen

There were no significant interaction effect between variety and levels of nitrogen. However, there were numerical differences when varietal performance increased. All the days it was found the BARI Sarisha- 13 and 180 kg N ha^{-1} produced the tallest plant height (Table 1). The smallest plant height was found from SAU Sarisha-1 and control treatment.

Table 1. Interaction effect of (variety and nitrogen) on plant height and total dry matter production of rapeseed at different days after sowing (DAS)

Variety × Nitrogen	Plant height (cm)					Total dry matter (g/plant)				
	30 DAS	45 DAS	60 DAS	75 DAS	At harvest	30 DAS	45 DAS	60 DAS	75 DAS	At harvest
V_1N_0	8.00	47.65	63.13	85.04	86.86	0.24	0.45	2.10	2.37	4.07
V_1N_1	9.00	58.54	70.64	96.08	98.01	0.34	0.85	2.57	2.97	5.48
V_1N_2	12.67	59.11	74.98	100.42	103.23	1.04	1.49	3.13	3.50	8.70
V_1N_3	12.33	59.35	77.99	103.43	104.55	1.13	2.49	4.54	4.77	8.69
V_2N_0	9.00	51.76	63.34	84.52	86.52	0.31	0.94	2.13	3.10	4.81
V_2N_1	10.00	54.29	75.09	100.53	102.53	0.40	1.23	2.67	3.83	6.17
V_2N_2	13.00	60.18	76.55	101.99	106.77	1.10	1.94	3.83	4.33	10.14
V_2N_3	12.67	62.52	81.00	106.44	108.03	1.20	2.94	4.80	5.03	10.68
V_3N_0	10.33	53.45	65.20	84.46	84.82	0.42	1.20	2.80	3.17	5.95
V_3N_1	11.33	61.01	76.96	102.40	103.68	0.51	1.65	3.30	5.00	6.88
V_3N_2	13.00	55.83	76.95	102.39	108.62	1.17	2.24	4.72	6.07	13.49
V_3N_3	14.33	63.86	81.33	106.77	107.54	1.33	2.94	5.43	7.27	13.67
$LSD_{0.05}$	**2.33**	**6.33**	**4.00**	**3.97**	**5.06**	**0.13**	**0.12**	**0.42**	**1.44**	**2.01**

V_1 = SAU Sarisha- 1
V_2 = BARI Sarisha- 11
V_3 = BARI Sarisha- 13

N_0 = Control
N_1 = 60 kg N ha^{-1}
N_2 = 120 kg N ha^{-1}
N_3 = 180 kg N ha^{-1}

4.2 Total dry matter (g/plant)

4.2.1 Effect of variety

Significant variation was found in total dry matter per plant among the different varieties in all growth stages. Distinct differences were observed in dry matter production after 30 DAS (Fig 3). These differences further increased at the successive stages. Wright *et al.* (1988) expressed the similar observation. The total dry matter production was increased with each increment of variety levels. At 30 DAS, treatment BARI Sarisha-13 (0.86g) produced the maximum dry matter which was statistically similar (0.75g) with BARI Sarisha-11 and the minimum dry matter production (0.69g) from SAU Sarisha-1. At 45 DAS, the maximum total dry matter produced (2.00g) by treatment of BARI Sarisha-13 and the minimum total dry matter from (1.32g) SAU Sarisha-1 which was statistically similar with (1.76g) BARI Sarisha-11. Similarly at 60 DAS, the maximum total dry matter produced (4.06g) by BARI Sarisha-13 and the minimum total dry matter from (3.09g) from SAU Sarisha-1 which was statistically similar with (3.36g) BARI Sarisha-11. At 75 DAS and at harvest both produced (5.38 and 10.00g) total dry matter in BARI Sarisha-13 and the minimum produced (3.40 and 6.74g) from SAU Sarisha-1 which was statistical similar with (4.07 and 7.95g) respectively (Appendix vii). The results revealed that the variety BARI Sarisha- 13, BARI Sarisha- 11 and SAU Sarisha- 1 had tall plant and more branching habit and that's why these varieties produced more branch and stem weight. These results ware in agreement with Chakraborty *et al.* (1991) who reported that dry matter production in crops was controlled by varietal characteristics.

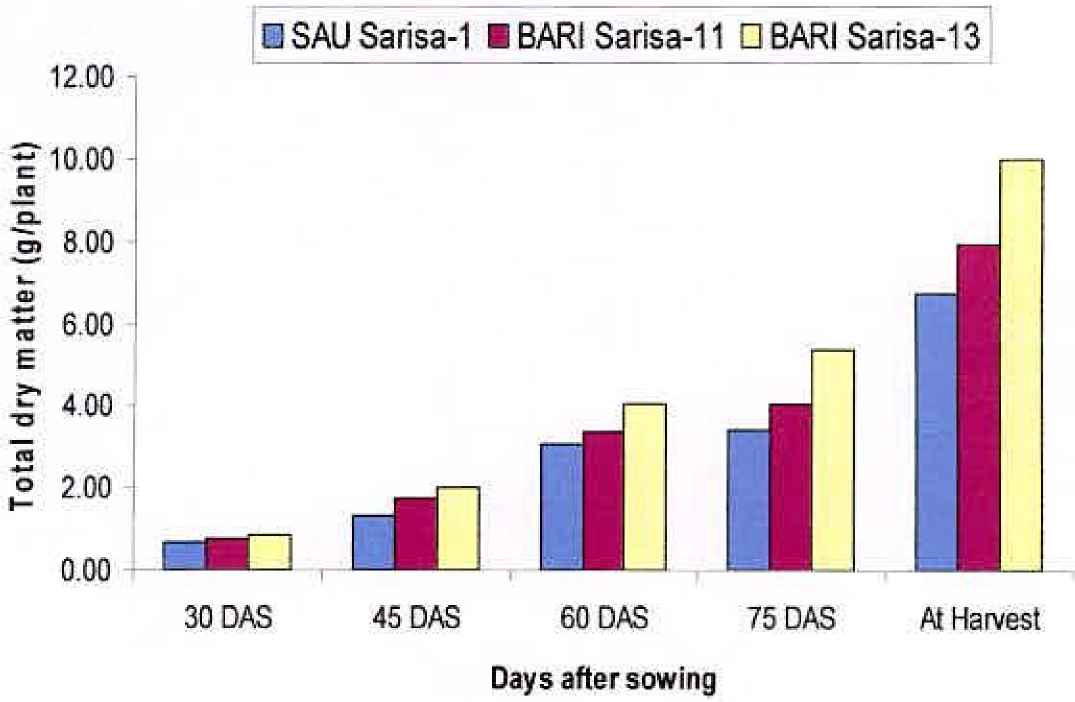

Fig 3. Effect of variety on total dry matter (g/plant) of rapeseed at different days after sowing (DAS)

4.2.2 Effect of nitrogen

The dry matter plant^{-1} at 30, 45, 60, 75 DAS and at harvest was higher due to nitrogen application. Each level of nitrogen significantly increased dry matter over preceding level (Fig. 4). Nitrogen at 180 kg ha^{-1} produced the highest dry matter per plant (1.22 g, 2.79 g, 4.92 g, 5.69 g and 11.02 g at 30, 45, 60, 75 DAS and at harvest) than 60 and 120 kg N application ha^{-1}. The yield of a crop depends on the dry matter production and amount of dry matter partitioning into its harvestable organ. The increase in the number of branches plant^{-1} may be ascribed to the functional role of nitrogen in the plant body. The chief functions of N are cell multiplication, cell elongation and tissue differentiation. With adequate supply of N the plants grew taller, produced more functional leaves with higher chlorophyll content. Thus photosynthesizing area might have increased resulting in greater production of dry matter plant^{-1}. So, at any given time the dry matter accumulation is a physiological index, which is closely related to the photosynthetic activity of leaves. These findings confirmed the observations of Kumar and Gangwar (1985), Tomar and Mishra (1991) and Upasani and Sharma

(1986). Bharati and Prasad (2003), Vyas *et al.* (1995), Singh *et al.* (2002), Shukla *et al.* (2002), Murtaza and Paul (1989), Mondal and Gaffer (1983) also obtained highest result at the rate of 180 kg N ha^{-1} on dry matter production.

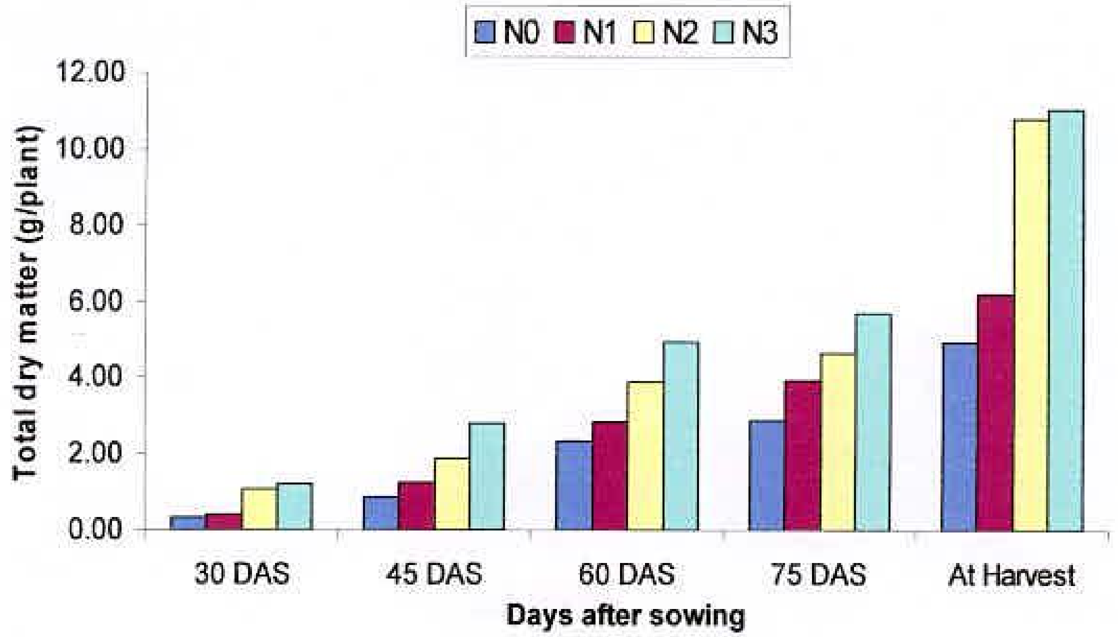

Fig. 4 Effect of levels of nitrogen on total dry matter (g/plant) of rapeseed at different days after sowing (DAS)

4.2.3 Interaction effect of variety and nitrogen

There was no significant difference in total dry matter production due to variety and levels of interaction (Table 1). Results showed that with increasing levels of nitrogen in all the varieties, numerically the total dry matter increased. Apparently the highest total dry matter was found from the treatment combination of variety BARI Sarisha-13 with 180 kg N ha^{-1}. The lowest total dry matter was found from the treatment combination of the variety SAU Sarisha 1 and control treatment (Table 1).

4.3 Number of primary branches $plant^{-1}$

4.3.1 Effect of variety

From the study it was found that variety had great influence on the number of primary branches per plant in rapeseed (Fig. 5). The maximum numbers of primary branches (2.51) were found from BARI Sarisha-13 and the lowest (1.73) numbers of primary branches were found from SAU Sarisha-1 treatment which was statistical similar than (1.79) BARI Sarisha-11(Table 2). Jahan and Zakaria (1997) observed 4.07 primary branches plant^{-1} in the local Tori-7 and Sampad which were at par BLN-900. The minimum primary branches plant^{-1} (2.90) was produced by Jataria.

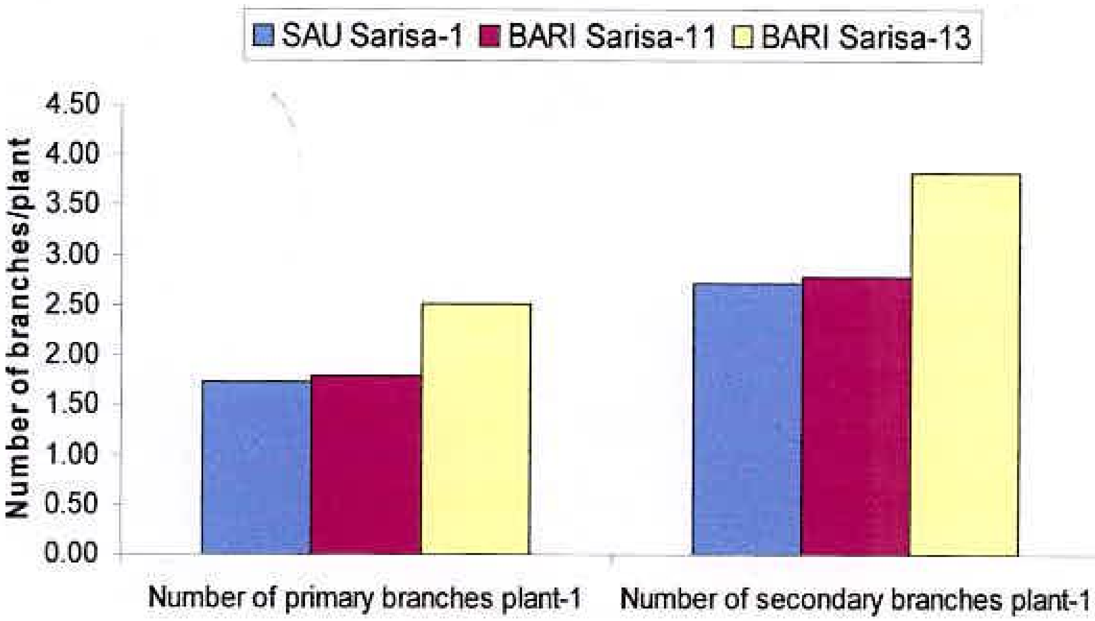

Fig. 5 Effect of variety on number of primary and secondary branches plant $^{-1}$ of rapeseed

4.3.2 Effect of nitrogen

Nitrogen fertilizer had significant effect on primary branches plant^{-1}. The levels of nitrogen (180 kg ha^{-1}) produced higher number of primary branches over the other doses (Fig. 6). Increasing rates of nitrogen increased the number of primary branches plant^{-1} and successive treatment differences were also significant (Table 3). So number of branches plant^{-1} influences the yield of rapeseed and it gradually increased with the increase in nitrogen fertilizers. This findings were supported by Tripathi and Tripathi (2003), Ozer (2003), Singh *et al.* (2003), Sharma and Jain (2002), Singh *et al.* (2002), Shukla *et al.* (2002), Patel (1998), Tarafder and

Mondal (1990), Shamsuddin *et al.* (1987), Mondal and Gaffer (1983) who obtained significant higher number of primary branches plant^{-1} by applying nitrogen up to 180 kg ha^{-1}.

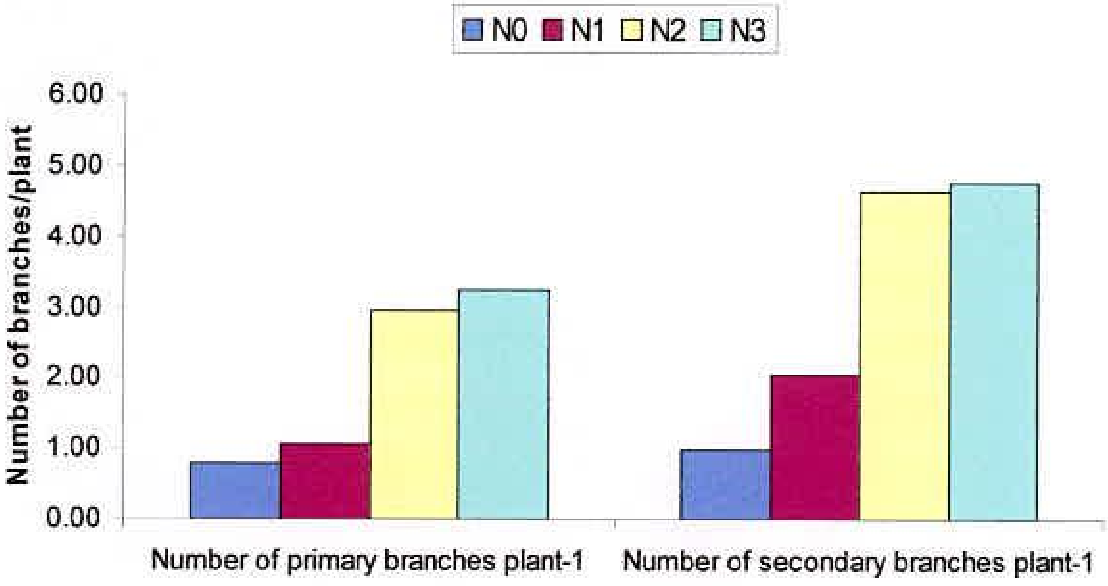

Fig. 6 Effect of nitrogen on number of primary and secondary branches plant^{-1} of rapeseed

4.3.3 Interaction effect of variety and nitrogen

It was observed that the combined effect of variety and nitrogen had showed significant difference to produce primary branches plant^{-1}. BARI Sarisha- 13 and 120 kgNha^{-1} was found the height (3.87) and the lowest (0.56) primary branches plant^{-1} from BARI Sarisha- 11 and control combined treatment.

4.4 Number of secondary branches plant^{-1}

4.4.1 Effect of variety

There was a significant variation in number of secondary branches plant^{-1} among the varieties (Fig.5). The variety BARI Sarisha- 13 produced the highest number of branches plant^{-1} (3.83) and lowest number of branches plant^{-1} (2.72) was produced by the variety SAU Sarisha- 1 which was statistically similar (2.78) with BARI Sarisha-11.

4.4.2 Effect of nitrogen

Nitrogen application favored to produce number of secondary branches plant^{-1} (Fig. 6). However, the significant increase was noted at the level of 180 kg N ha^{-1} which was 4.77 kg N ha^{-1} compared to 60, 120 kg N ha^{-1} and control (Table 3). Singh *et al.* (2003) and Singh *et al.* (2002) obtained increased number of the secondary branches plant^{-1} with nitrogen at 180 kg ha^{-1}. Ali and Ullah (1995) observed the similar trend incase in number of branches plant^{-1} with the increase in nitrogen levels. Number of branches plant^{-1} was highly responsive to nitrogen reported by Prakash and Verma (1997) and Ali and Rahman (1986). But Sharma and Jain (2002) reported higher secondary branches plant^{-1} at the rate of 80 kg N ha^{-1}.

4.4.3 Interaction effect of variety and nitrogen

The treatment combination of variety and nitrogen had significant effect on secondary branches plant^{-1} (Table 4). In the present work, it might be concluded that BARI Sarisha- 13 and 180 kg N ha^{-1} produced (5.67) maximum number of secondary branches plant^{-1} and the lowest number of secondary branches plant^{-1} (0.83) were produced from the SAU Sarisha-1 in combination with control treatment.

4.5 Length of main inflorescence

4.5.1 Effect of variety

From the study, it was found that variety had significant effect on the length of main inflorescence (Table 2). The Variety BARI Sarisha- 13 produced highest length of main inflorescence (62.86 cm) and the lowest (54.68 cm) from the SAU Sarisha-1 treatment.

4.5.2 Effect of nitrogen

Nitrogen fertilizer had significant effect on the length of main inflorescence. The rate of 120 and 180 kg N ha^{-1} showed significant effect on length of main inflorescence (67.27 and 67.88 cm respectively) and SAU Sarisha-1 gave the lowest one (47.61 cm) (Table 3). However, the differences between 80 and 180 kg N ha^{-1} were not found significant. The main functions of N are cell multiplication, cell elongation and tissue differentiation. With adequate supply of N the plants grew taller, produced more functional leaves with higher chlorophyll content.

4.5.3 Interaction effect of variety and nitrogen

A significant variation was seen in the treatment combination of variety BARI Sarisha-13 and the rate of 120 kg N ha^{-1} produced the highest length (73.17 cm) of main inflorescence (Table 4) which was also similar with the BARI Sarisha- 13 and 180 kg N ha^{-1}.

4.6 Number of siliquae in the main inflorescence

4.6.1 Effect of variety

Number of siliquae is an important factor for increasing yield, which is adversely supported by variety. Number of siliquae in the main inflorescence was significantly affected by the variety in this study. The maximum (47.84) number of siliquae were found in SAU Sarisha- 1 (Table 2) and the minimum siliquae (43.93) from BARI Sarisha-11. Mondal *et al.* (1992) observed the maximum number of siliquae (51.22) in the variety J-5004 which was identical with the variety Tori-7 and the lowest number of siliquae (41.9) was found in the variety SS-75.

4.6.2 Effect of nitrogen

Application of N at 180 kg ha^{-1} significantly increased the number of siliquae in the main inflorescence (50.18) which was statistically identical with (49.25) 120 N kg ha^{-1}over control (40.69) Table 3. The higher number of siliquae with higher rates of N was might be due to higher LAI, which resulted in a greater number of siliquae being carried by each inflorescence.

4.6.3 Interaction effect of variety and nitrogen

From the study, it was also observed that treatment combination of variety and nitrogen had significant effect on number of siliquae in the main inflorescence. SAU Sarisha 1 and 180 kg N ha^{-1} produced maximum number of siliquae in the main inflorescence (53.37). The combination of variety with adequate supply of N the plants grew taller, ultimately produced more number of siliquae in the main inflorescence.

4.7 Number of siliquae $plant^{-1}$

4.7.1 Effect of variety

Number of siliquae is an important factor for increasing yield, which is adversely supported by variety. Number of siliquae in the main inflorescence was significantly affected by variety in this study. The maximum (98.78) numbers of siliquae were found in BARI Sarisha- 13 (Table 2) which was statistically identical with (95.71) BARI Sarisha- 11 and the minimum siliqua (82.34) from SAU Sarisha-1. Mondal *et al.* (1992) observed the maximum number of siliquae $plant^{-1}$ (136) in the variety J-5004 which was identical with the variety Tori-7 and the lowest number of siliquae $plant^{-1}$ (45.9) was found in the variety SS-75.

4.7.2 Effect of nitrogen

Nitrogen fertilizer had significant effect on number of siliquae $plant^{-1}$. The rate of 120 kg N ha^{-1} showed highest number of siliquae $plant^{-1}$ (108.64) which was statistically identical with 180 kg N ha^{-1} and the lowest one (68.71) from control (Table 3). Similar results were also supported by Shukla *et al.* (2002), Singh *et al.* (2003), Singh *et al* (2002), Tarafder and Mondal (1990) and Shamsuddin *et al.* (1987). On the other hand, higher number of siliquae $plant^{-1}$ obtained at 80 kg N ha^{-1} by Khan *et al.* (2003), Sharma and Jain (2002), Patel (1998). Seed yield increased mainly due to greater number of siliquae $plant^{-1}$ and seeds $siliqua^{-1}$. The number of siliquae $plant^{-1}$ increased linearly with increasing rates of N. The higher number of siliquae with higher rates of N was might be due to higher LAI, which resulted in a greater number of siliquae being carried by each inflorescence.

Greater number of siliquae was associated with higher LAI, which combined with larger LAD, led to higher final seed yield of rapeseed.

4.7.3 Interaction effect of variety and nitrogen

From the study, it was also observed that treatment combination of variety and nitrogen had significant effect on number of siliquae plant^{-1}.BARI Sarisha-11 at 120 kg N ha^{-1} was produced (115.30) maximum number of siliquae plant^{-1} which was statistically identical (114.57) with BARI Sarisha- 13 and 120 kg N ha^{-1}. The combination of variety with adequate supply of N the plants grew taller, ultimately produced more number of siliquae plant^{-1}.

4.8 Length of siliqua (cm)

4.8.1 Effect of variety

Variety had no significant effect on the siliquae length. Generally it was that length of siliqua is a genetical factor (Table 2).

4.8.2 Effect of nitrogen

Nitrogen had also insignificant effect on the siliquae length. Generally it was that length of siliqua is a genetical factor (Table 3).

4. 8.3 Interaction effect of variety and nitrogen

In this study, interaction effect of variety and nitrogen showed not significant effect on siliquae length (Table 4).

4.9 Number of seeds siliqua^{-1}

4.9.1 Effect of variety

Number of seeds siliqua^{-1} was significantly affected by variety. The highest number (27.30) of seeds siliqua^{-1} was observed in BARI Sarisha- 13 and the lowest number of seed was found from BARI Sarisha- 11 (Table 2). Seed siliqua^{-1} varied differently indifferent varieties due to the genetical character which performed to elongate the siliquae length and have more number of seeds.

4.9.2 Effect of nitrogen

Nitrogen rates significantly influenced the number of seeds siliqua^{-1}. The number of seeds siliqua^{-1} was increased with the increase of nitrogen rates (Table 3). The significant highest number of seeds siliqua^{-1} (29.23) was found with the rate of 120 kg N ha^{-1} which was identical (29.04) with 180 kg N ha^{-1}. Seeds siliqua^{-1} increased with the increasing levels of nitrogen up to a certain levels and thereafter declined. It might be due to the excess amount of nitrogen plant^{-1} became more vigorous. Similar response in number of seed siliqua^{-1} that were obtained by Singh (2002), Shukla *et al.* (2002), Tarafder and Mondal (1990), Sharma and Jain (2002) obtained higher number of seeds siliqua^{-1} at the rate of 80 kg N ha^{-1}. Patel (1998) also obtained similar response of nitrogen on number of seeds siliqua^{-1}. It might be due to the fact that vigorous vegetative growth due to nitrogen resulted in adequate supply of photosynthesis for the formation of siliqua.

4.9.3 Interaction effect of variety and nitrogen

Variety as well as nitrogen interact each other to produce seeds siliqua^{-1} in rapeseed. An insignificant variation in the number of seeds siliqua^{-1} was found with the different interaction of variety and nitrogen in this study (Table 4).

4.10 Weight of 1000 seeds (g)

4.10.1 Effect of variety

Variety had significant effect on the weight of 1000 seeds (g). The seed weight in terms of 1000-seed varied significantly at 1% level among the varieties. The variety BARI Sarisha- 13 produced the heaviest seed (3.61 g) and the lowest 1000-seed weight (3.21g) was produced by SAU Sarisha- 1 (Table 2).Variety BARI Sarisha- 11 produced intermediate 1000-seed of 3.31 g.

4.10.2 Effect of nitrogen

From Table 3. it was reveled that the application of nitrogen at 60, 120 and 160 kg ha^{-1} had significant effect on 1000 seed weight. The 1000 seed weight increased with the increase of nitrogen levels. At the rate of 120 kg N ha^{-1} produced maximum seed weight (3.62 g) and control treatment gave the lowest one (3.03 g). Sharma and Jain (2002) also obtained highest 1000 seed weight at 80 kg N/ ha. But, Ozer (2003), Singh *et al.* (2002), Shukla *et al.* (2002) and Shamsuddin *et al.* (1987) obtained highest 1000 seed weight N at 120 kg ha^{-1}. Singh (2002) conducted an experiment with Varuna variety of mustard having 5 levels of nitrogen (0, 30, 60, 90 and 120 kg ha^{-1}) and five levels of P (0, 15, 30, 45 and 60 kg ha^{-1}). Application of N and P increased 1000 seed weight. However, the significant increase in 1000 seed weight was recorded up to 120 kg N ha^{-1}. It might be due to enhanced growth attributes that diverted the photosynthesis to reproductive organs for the formation of large sized, number of seeds of higher seed weight that ultimately increased the yield ha^{-1}. So seed yield of rapeseed was greatly influenced by 1000 seed weight.

4.10.3 Interaction effect of variety and nitrogen

Interaction effect of variety and nitrogen was found significant in relation to 1000 seed weight of rapeseed (Table 4). The highest weight of 1000 seed (3.94 g) was found from the combination of BARI Sarisha- 13 at 180 kg N ha^{-1}, it was statistically similar with BARI Sarisha- 13 with 120 kg N ha^{-1}. The 1000 seed weight increased with the increasing levels of variety and nitrogen reported by Abadi *et al.* (2001) Tomar *et al.* (2001), Singh *et al.* (1998). Mondal *et al.* (2000) obtained significant higher 1000 seed weight by applying two varieties along with 80 kg N ha^{-1}.

Table 2. Effect of variety on yield and yield contributing characters of rapeseed

Variety	Length of main inflorescence (cm)	Number of siliquae in the main inflorescence	Number of siliquae plant^{-1}	Length of siliqua (cm)	Number of seeds siliqua^{-1}	Weight of 1000 seeds (g)	Harvest index (%)
V_1	54.68	47.84	82.34	7.51	25.65	3.21	43.41
V_2	58.82	43.93	95.71	7.61	23.95	3.31	43.59
V_3	62.86	45.66	98.78	7.70	27.30	3.61	41.96
$LSD_{0.05}$	1.54	0.89	2.48	NS	0.55	0.03	0.2

V_1 = SAU Sarisha- 1
V_2 = BARI Sarisha- 11
V_3 = BARI Sarisha- 13

Table 3. Effect of levels of nitrogen on yield and yield contributing characters of rapeseed

Nitrogen	Length of main inflorescence (cm)	Number of siliquae in the main inflorescence	Number of siliquae plant^{-1}	Length of siliqua (cm)	Number of seeds siliqua^{-1}	Weight of 1000 seeds (gm)	Harvest index (%)
N_0	47.61	40.69	68.71	7.46	21.41	3.03	41.44
N_1	52.39	43.13	83.49	7.72	22.87	3.43	43.56
N_2	67.88	49.25	108.64	7.81	29.23	3.62	45.17
N_3	67.27	50.18	108.27	7.44	29.04	3.43	41.78
$LSD_{0.05}$	1.78	1.02	2.86	NS	0.63	0.04	0.23

N_0 = Control
N_1 = 60 kg N ha^{-1}
N_2 = 120 kg N ha^{-1}
N_3 = 180 kg N ha^{-1}

Table 4. Interaction effect of variety and nitrogen on yield and yield contributing characters of rapeseed at different days after sowing (DAS)

Variety × Nitrogen	Number of primary branches plant^{-1}	Number of secondary branches plant^{-1}	Length of main inflorescence (cm)	Number of siliquae in the main inflorescence	Number of siliquae plant^{-1}	Length of siliqua (cm)	Number of seeds siliqua^{-1}	Weight of 1000 seeds (g)
V_1N_0	0.77	0.83	47.07	43.37	63.36	7.41	21.02	3.02
V_1N_1	1.17	1.60	50.31	44.95	72.83	7.62	22.41	3.34
V_1N_2	2.04	4.23	60.24	49.69	97.50	7.56	29.87	3.36
V_1N_3	2.92	4.23	61.11	53.37	95.67	7.46	29.31	3.15
V_2N_0	0.56	0.86	46.79	38.23	69.50	7.48	20.11	3.03
V_2N_1	0.65	1.58	49.56	41.53	85.68	7.85	21.47	3.28
V_2N_2	2.90	4.27	70.23	48.13	113.12	8.01	27.23	3.73
V_2N_3	3.06	4.40	68.70	47.83	114.56	7.11	27.01	3.21
V_3N_0	1.06	1.23	48.98	40.47	73.29	7.51	23.1	3.03
V_3N_1	1.37	2.97	57.29	42.90	91.97	7.68	24.71	3.67
V_3N_2	3.87	5.43	73.17	49.92	115.30	7.86	30.58	3.79
V_3N_3	3.77	5.67	72.00	49.34	114.57	7.75	30.82	3.94
$LSD_{0.05}$	0.24	0.30	3.09	1.77	4.96	NS	1.09	0.06

V_1 = SAU Sarisha- 1
V_2 = BARI Sarisha- 11
V_3 = BARI Sarisha- 13

N_0 = Control
N_1 = 60 kg N ha^{-1}
N_2 = 120 kg N ha^{-1}
N_3 = 180 kg N ha^{-1}

4.11 Seed yield (kg ha^{-1})

4.11.1 Effect of variety

The seed yield of rapeseed significantly differed among the varieties. BARI Sarisha- 13 produced the highest yield of 1797.25 kg ha^{-1} and the lowest seed yield (1603.13 kg ha^{-1}) was obtained from the variety SAU Sarisha- 1. The variety BARI Sarisha- 11 produced intermediate seed yield of 1679.76 kg ha^{-1} (Fig. 7). The above results indicate a presence of substantial variation in this character among the varieties. Production of the highest seed yield by the variety BARI Sarisha- 13 might be due to the contribution of cumulative favorable effects of the crop characteristics viz. number of branch plant^{-1}, pods plant^{-1}, and seeds pod^{-1}. It has been reported that the higher seed yield was positively correlated with plant height, branches plant^{-1}, pods plant^{-1}, seeds pod^{-1} and 1000-seeds weight. Rahman (2002) observed higher seed yield in BARI sharisa-7, BARI sharisa-8 and BARI sharisa-11 (2.00-2.50 t ha^{-1}) and the lowest yield in variety Tori-7 (0.95-1.10 t ha^{-1}).

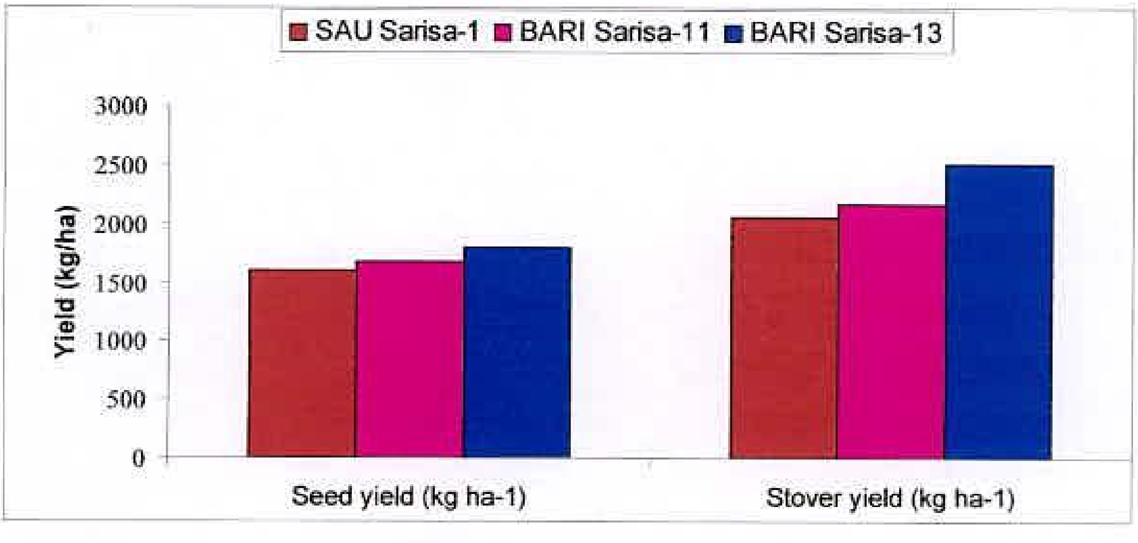

Fig. 7 Effect of variety on seed and stover yield (ka ha^{-1}) of rapeseed

4.11.2 Effect of nitrogen

Different rates of nitrogen significantly increased the seed yield ha^{-1}. Nitrogen at 120 kg N ha^{-1} significantly increased the seed yield (1974.62 kg ha^{-1}) which was identical (1911.23 kg ha^{-1}) with 180 kg N ha^{-1} over control (1262.91 kg ha^{-1}) and 60 kg N ha^{-1} (1624.76 kg ha^{-1}). Seed yield increased with the increasing rates of nitrogen fertilizer application up to 120 kg N ha^{-1} and thereafter declined (Fig. 8). Higher seed yield was also obtained with same nitrogen rate as reported by Singh and Prasad (2003), Singh *et al.* (2003), Shukla *et al.* (2002), Singh (2002), Singh *et al.* (2002), Shukla and Kumar (1997), Tuteja *et al.* (1996), Shamsuddin *et al.* (1987). In some cases the highest seed yields kg ha^{-1} were obtained by Singh (2004), Sharma and Jain (2002), Ghosh *et al.* (2001), Khan *et al.* (2003), Singh *et al.* (1998) and Thakuria and Gogoi (1996) at 80 kg N ha^{-1}. Increase in the seed yield of rapeseed due to increasing nitrogen levels may be attributed to the favorable improvement in all the yield attributes with N fertilization. But access doses of nitrogen at any plant become more vigorous, it may be duration of plant life (mainly vegetative part) cycle elongation and they do not complete their reproductive part. So, plant becomes comparatively less productive.

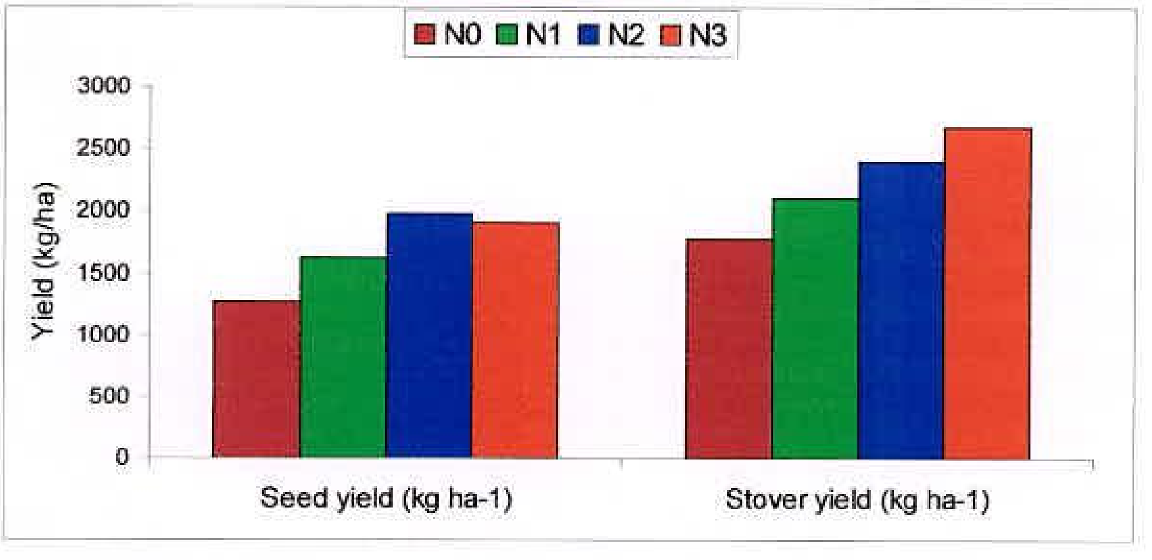

Fig. 8. Effect of levels of nitrogen on seed and stover yield (kg ha^{-1}) of rapeseed

4.11.3 Interaction effect of variety and nitrogen

Interaction Effect of variety and nitrogen influenced the seed yield ha^{-1} and seed yield was significantly superior (2029.19 kg ha^{-1}) at BARI Sarisha-13 with 120 kg N ha^{-1} which was similar (2014.58 kg ha^{-1}) with 120 kg N ha^{-1} and minimum seed yield was (1097.76 kg ha^{-1}) at SAU Sarisha-1 with control treatment (Table-5).

4.12 Stover yield (kg ha^{-1})

4.12.1 Effect of variety

The highest stover yield 2505.38 kg ha^{-1} produced by the variety BARI Sarisha- 13 and the lowest stover yield was 2169.95kg ha^{-1} from the variety BARI Sarisha- 11 (Fig. 7). Variety BARI Sarisha- 13 and BARI Sarisha- 11 are of tall plant type and more branching habit which have contributed towards producing more stover yield.

4.12.2 Effect of nitrogen

The nitrogen application favorably influenced the stover yield and the difference among the consecutive levels was significant. The application of 180 kg N ha^{-1} gave significantly highest stover yield (2681.39 kg ha^{-1}) over 60 and 120 kg N ha^{-1}(2107.90 and 2411.48 kg ha^{-1} respectively) and control (1777.35 kg ha^{-1}). These findings were in agreement with that of Singh and Prasad (2003), Singh *et al.* (2002). But, Meena *et al.* (2002) observed higher stover yield of mustard at the nitrogen rate of 60 kg ha^{-1}. It might be due to increasing rate of nitrogen up to 180 kg ha^{-1}, increases the plant height, dry matter, number of branches and length of the main inflorescence and ultimately increased the stover yield.

4.12.3 Interaction effect of variety and nitrogen

Interaction effect of variety and nitrogen had significant effect on stover yield. The highest (3065.88 kg ha^{-1}) stover yield was found from BARI Sarisha- 13 with 180 kg N ha^{-1}. The BARI Sarisha- 13 with the rate of nitrogen at 180 kg ha^{-1} showed the result that was statistically different from other treatments and the lowest stover yield from SAU Sarisha- 1 and control treatment (Table-5).

4.13 Harvest index (%)

Harvest index is the ratio of economic yield and biological yield and it was influenced by different variety and nitrogen levels which was shown.

4.13.1 Effect of variety

It was observed from the table 4 that different varieties had significant effect on harvest index. Among the three varieties, BARI Sarisha- 11 gave the highest harvest index (43.59%) which was statistically identical (43.41%) with SAU Sarisha- 1 and the lowest value of harvest index (41.96%) was obtained from the treatment BARI Sarisha- 13 (Table-2).

4.13.2 Effect of nitrogen

From Table 3 it revealed that the different nitrogen levels had significant effect on harvest index. Application of nitrogen at 120 kg ha^{-1} significantly increased the harvest index (45.17%) followed by 60 and 180 kg ha^{-1} (43.56% and 41.78% respectively) and control (41.44%). Highest harvest index observed at 120 kg N ha^{-1}. Similar result was also observed by Shukla and Kumar (1997) at the same nitrogen level.

4.13.3 Interaction effect of variety and nitrogen

It was observed that variety and nitrogen interaction had significant effect on harvest index. Harvest index was significantly higher in BARI Sarisha- 11 in combination with 120 kg N ha^{-1} and produced lower harvest index (39.14%) from SAU Sarisha- 1 in combination with control treatment (Table-5).

Table 5. Interaction effect of variety and nitrogen on seed yield (kg ha^{-1}), stover yield (kg ha^{-1}) and harvest index (%) of rapeseed

Variety × Nitrogen	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)
V_1N_0	1097.76	1707.18	39.14
V_1N_1	1526.83	1971.63	43.65
V_1N_2	1890.77	2241.07	45.77
V_1N_3	1897.17	2313.17	45.06
V_2N_0	1284.7	1773.7	42.02
V_2N_1	1608.5	2036.09	44.13
V_2N_2	2003.92	2204.9	47.61
V_2N_3	1821.94	2665.11	40.61
V_3N_0	1406.27	1851.18	43.17
V_3N_1	1738.97	2315.97	42.89
V_3N_2	2029.19	2788.48	42.12
V_3N_3	2014.58	3065.88	39.66
$LSD_{0.05}$	7.86	34.51	0.4

V_1 = SAU Sarisha- 1 N_0 = Control
V_2 = BARI Sarisha- 11 N_1 = 60 kg N ha^{-1}
V_3 = BARI Sarisha- 13 N_2 = 120 kg N ha^{-1}
N_3 = 180 kg N ha^{-1}

Chapter 5
Summary and Conclusion

Chapter 5

SUMMARY AND CONCLUSION

An experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka-1207, during the period from November, 2006 to March, 2007 with a view to examining the effect of nitrogen on the yield of three rapeseed varieties. There were 4 nitrogen fertilizer treatments in the experiment such as N_0 = Control, N_1 = 60 kg N ha^{-1}, N_2 = 120 kg N ha^{-1} and N_3 = 180 kg N ha^{-1} and three verities viz. SAU Sharisha-1, BARI Sharisha-11 and BARI Sharisha-13 were used in the experiment as the test crop. The experiment was laid out in Randomized Complete Block Design (RCBD) (factorial) with three replications. The total numbers of plots were 12×3=36. The size of each unit plot was 2.7m×4m=10.8 m^2. Plant height (cm) at 30, 45, 60, 75 DAS and at harvest, dry matter (g/plant) at 30, 45, 60 and 75 days after sowing and at harvest, number of primary branches plant^{-1}, number of secondary branches plant^{-1}, length of main inflorescence (cm), number of siliquae in the main inflorescence, number of siliquae plant^{-1}, length of siliqua (cm), number of seeds siliqua^{-1}, weight of 1000 seeds (g), seed yield (kg ha^{-1}), stover yield (kg ha^{-1}) and harvest index (%) of rapeseed were observed and average value was recorded. Plant height (cm) at 30, 60, 75 days and at harvest, dry matter (g/plant) at 30, 45, 60, 75 days after sowing and at harvest, number of primary branches plant^{-1}, number of secondary branches plant^{-1}, length of main inflorescence (cm), number of siliquae in the main inflorescence, number of siliquae plant^{-1}, number of seeds siliqua^{-1}, weight of 1000 seeds (g), seed yield (kg ha^{-1}), stover yield (kg ha^{-1}) and harvest index (%) of rapeseed were significant among the three varieties and levels of nitrogen treatments but plant height (cm) at 45 DAS, length of siliqua (cm) and did not differed significantly. Although the interaction effect in case of plant height (cm) at 30, 45, 60, 75 DAS and at harvest, dry matter (g/plant) at 30, 60, 75 days after sowing and at harvest, number of primary branches plant^{-1}, number of secondary branches plant^{-1}, length of main inflorescence (cm), number of siliquae in the main inflorescence, number of siliquae plant^{-1}, weight of 1000 seeds (g), seed yield (kg ha^{-1}), stover yield (kg ha^{-1}) and harvest index (%) did not differ significantly. Plant height at 30 , 60 and 75 DAS and at harvest of rapeseed was significant, except 45 DAS. At 30 DAS the tallest plant height (12.25cm) observed from BARI Sarisha-13 and smallest (10.50cm) from SAU Sarisha-1. The tallest plants at 60 DAS, 75 DAS and at harvest were observed (75.11, 99.01 and 101.17cm, respectively) in the treatment of BARI Sarisha-13. Application of 180 kg N ha^{-1} produced the tallest plant height and the shortest plant height was produced due to control treatment. There were no significant interaction effect between variety and levels of nitrogen.

Significant variation was found in total dry matter production plant^{-1} among the different varieties in all growth stages. BARI Sarisha-13 produced the maximum dry matter at all the growth stages (0.86g, 2.00g, 4.06g, 5.38 and 10.00g), respectively. There was no significant difference in total dry matter due to variety and levels of interaction.

The maximum numbers of primary branches (2.51) were found from BARI Sarisha-13 and the lowest (1.73) numbers of primary branches were found from SAU Sarisha-1. Nitrogen fertilizer had significant effect on primary branches plant^{-1}. The levels of nitrogen (180 kg ha^{-1}) produced higher number of primary branches over the other doses. The combined effect of variety and nitrogen had showed significant difference to produce primary branches plant^{-1}. BARI Sarisha-13 and 120 kg N ha^{-1} was found the highest (3.87) and the lowest (0.56) primary branches plant^{-1} from BARI Sarisha- 11 and control treatment. There was a significant variation in number of secondary branches plant^{-1} among the varieties. The variety BARI Sarisha- 13 produced the highest number of branches plant^{-1}

(3.83) and lowest number of branches plant^{-1} (2.72) was produced by the variety SAU Sarisha- 1. The treatment combination of variety and nitrogen had significant effect on secondary branches plant^{-1}.

Number of siliquae is an important factor for increasing yield, which is adversely supported and significantly affected by variety. The maximum (47.84) number of siliquae found in SAU Sarisha- 1 and the minimum siliqua (43.93) from BARI Sarisha-11. Application of N at 180 kg ha^{-1} significantly increased the number of siliquae in the main inflorescence (50.18) over control (40.69. Variety and nitrogen had significant effect on number of siliquae in the main inflorescence. SAU Sarisha- 1 and 180 kg N ha^{-1} produced maximum number of siliquae in the main inflorescence (53.37). Number of siliquae plant^{-1} was significantly affected by variety in this study. The maximum (98.78) number of siliqua plant^{-1} found in BARI Sarisha- 13. Nitrogen fertilizer had significant effect on number of siliquae plant^{-1}. The rate of 120 kg N ha^{-1} showed highest number of siliquae plant^{-1} (108.64) and the lowest (68.71) from control. The combination of variety and nitrogen had significant effect on number of siliquae plant^{-1}. BARI Sarisha- 11 and 120 kg N ha^{-1} produced (115.30) maximum number of siliquae plant^{-1}.

Number of seeds siliqua^{-1} was significantly affected by variety. The highest number (27.30) of seeds siliqua^{-1} was observed in BARI Sarisha- 13. Nitrogen rates significantly influenced the number of seeds siliqua^{-1}. The significant highest number of seeds siliqua^{-1} (29.23) was found with the rate of 120 kg N ha$^{-1.}$ Varieties as well as nitrogen interact with each other to produce seeds siliqua^{-1} in rapeseed.

Variety had significant effect on the weight of 1000 seeds (g). The variety BARI Sarisha- 13 produced the heaviest seed (3.61 g) and at the rate of 120 kg N ha^{-1} produced maximum seed weight (3.62 g). The highest weight of 1000 seed (3.94 g) was found from the combination of BARI Sarisha- 13 at 180 kg N ha^{-1}, it was statistically similar with BARI Sarisha- 13 with 120 kg N ha^{-1}.

The seed yield of rapeseed significantly differed among the varieties. BARI Sarisha- 13 produced the highest yield of 1797.25 kg ha^{-1} and the lowest seed yield (1603.13 kg ha^{-1}) was obtained from the variety SAU Sarisha- 1. Different rates of nitrogen significantly increased the seed yield ha^{-1}. Nitrogen at 120 kg ha^{-1} was significantly increased the seed yield (1974.62 kg ha^{-1}). Seed yield decreased with the decreasing rates of nitrogen fertilizer application. Interaction effect of variety and nitrogen influenced the seed yield ha^{-1} significantly (2029.19 kg ha^{-1}) at BARI Sarisha- 13 with 120 kg N ha^{-1}.

From the present study, it might be concluded that variety and nitrogen influenced the growth, yield and yield components of rapeseed. Among the treatments combination BARI Sarisha-13 with 120 kg N ha^{-1} gave the best result although but seed yield increased with the increasing rates of nitrogen fertilizer application up to 120 kg N ha^{-1} and thereafter declined. Excess dose of fertilizer damage the soil fertility and increase the cost of production.

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APPENDICES

Appendix I: Morphological, physical and chemical characteristics of initial soil (0-15 cm depth)

A. Physical composition of the soil

Soil separates	(%)	Methods employed
Sand	36.90	Hydrometer method (Day, 1996)
Silt	26.40	-do-
Clay	36.66	-do-
Texture class	Clay loam	-do-

B. Chemical composition of the soil

Sl.	Soil characteristics	Analytical data	Methods employed
1	Organic carbon (%)	0.82	Walkley and Black, 1947
2	Total N (kg/ha)	1790.00	Bremner & Mulvaney, 1965
3	Total S (ppm)	225.00	Bardsley and Lancster, 1965
4	Total P (ppm)	840.00	Olsen and Sommers, 1982
5	Available N (kg/ha)	54.00	Bremner , 1965
6	Available P (kg/ha)	69.00	Olsen and Dean, 1965
7	Exchangeable K (kg/ha)	89.50	Pratt ,1965
8	Available S (ppm)	16.00	Hunter, 1984
9	PH (1:2.5 soil to water)	5.55	Jackson, 1958
10	CEC	11.23	Chapman, 1965

Source: SRDI

Appendix II: Monthly average of temperature, relative humidity, total rainfall and sunshine hour of the experimental site during the period from November 2006 to March 2007

Year	Month	Air temperature (°c)			Relative humidity (%)	Rainfall (mm)	Sunshine (hr)
		Maximum	Minimum	Mean			
2006	November	30.35	24.6	27.60	80	322	132.20
	December	30.10	19.8	24.45	77	03	197.63
2007	January	23.23	18.2	21.75	65	0	155.10
	February	29.21	19.4	25.35	60	0	161.01
	March	26.11	15.7	21.4	62	Trace	207.03

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka- 1212.

Appendix III. Chemical composition of some *Brassica* oilseeds

Species	Seed (%)				Free fatty acid (%)	Nutrient content in oil cake (%)				
	Moisture	Oil	Protein	Ash		N	P	K	Ca	Mg
Brassica campestris	6.0	46.38	17.34	3.74	0.28	5.18	0.71	1.45	0.35	0.27
Brassica napus	7.3	39.37	22.99	5.31	1.18	6.07	0.59	1.77	0.40	0.27
Brassica juncea	6.0	44.30	23.60	3.84	4.45	6.78	0.65	1.13	0.48	0.31
Brassica carinata	6.4	39.89	21.67	4.65	0.56	5.76	0.49	0.93	0.82	0.25
Brassica nigra	6.7	28.96	28.77	3.76	0.71	6.48	0.79	1.29	0.60	0.22

Source: Pathak *et al.* (1973)

Appendix IV: ANOVA for plant height and dry matter

Source of variation	d. f.	Mean square									
		Plant height					Dry matter				
		30 DAS	45 DAS	60 DAS	75 DAS	At harvest	30 DAS	45 DAS	60 DAS	75 DAS	At harvest
R	2	1.194	17.862	16.257	2.171	7.767	0.001	0.009	0.039	0.186	1.659
Factor A (V)	2	9.361**	17.003**	36.669**	25.161**	33.773**	0.086**	1.444**	3.048**	12.092**	32.661**
Factor B (N)	3	36.028**	189.267**	430.584**	750.532**	838.823**	1.913**	6.393**	11.845**	12.589**	87.745**
AB (V x N)	6	0.806^{NS}	25.268^{NS}	4.119^{NS}	6.756^{NS}	9.95^{NS}	0.001^{NS}	0.03^{NS}	0.14^{NS}	0.807^{NS}	2.831^{NS}
Error	**22**	**1.71**	**13.135**	**4.676**	**5.1**	**7.784**	**0.005**	**0.004**	**0.073**	**0.762**	**1.273**
CV (%)		**11.57**	**6.33**	**2.94**	**2.31**	**2.79**	**9.52**	**3.93**	**7.73**	**15.38**	**13.71**

Note: Single and double sterisks indicate significant at 5% and 1% levels respectively. NS means non significant, R =Replication, V=Variety and N= Nitrogen.

Appendix V: ANOVA for yield attributes

Source of variation	d. f.	Mean square							
		No. of primary branches/plant	No. of secondary branches/plant	Length of main inflorescence	No. of siliquae in the main inflorescence	Siliquae per plant	Siliquae length (cm)	Seeds per siliqua	1000 seed weight(g)
R	2	0.018	0.335	7.285	24.952	4.818	0.085	3.73	0.008
Factor A (V)	2	2.286**	4.631**	200.583**	46.137**	917.079**	0.107**	33.66**	0.502**
Factor B (N)	3	14.279**	32.357**	961.363**	193.018**	3467.292**	0.305**	150.132**	0.569**
AB (V x N)	6	0.474*	0.223*	29.823**	3.367**	27.756**	0.137^{NS}	0.714**	0.127**
Error	**22**	**0.018**	**0.036**	**3.735**	**0.92**	**7.505**	**0.207**	**0.338**	**0.012**
CV (%)		**6.75**	**6.07**	**3.29**	**2.09**	**2.97**	**5.98**	**2.27**	**3.27**

Note: Single and double sterisks indicate significant at 5% and 1% levels respectively. NS means non significant, R =Replication, V=Variety and N= Nitrogen.

Appendix VI: ANOVA for yield, harvest index and oil content

Source of variation	d. f.	Mean square		
		Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)
R	2	140.091	1763.378	0.218
Factor A (V)	2	114716.8**	649792.9**	9.56**
Factor B (N)	3	949709.4**	1366920**	26.799**
AB (V x N)	6	12220.14**	70870.2**	17.607**
Error	22	**185.541**	**3573.507**	**0.472**
CV (%)		**3.80**	**2.66**	**1.60**

Note: Single and double sterisks indicate significant at 5% and 1% levels respectively. NS means non significant, R =Replication, V=Variety and N= Nitrogen.